2014 Annual Report

Illinois Volunteer Lake Monitoring Program

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Acknowledgements

First and foremost, thanks to the 234 volunteer lake scientists who make this program a possibility. Their dedication to Illinois lakes is greatly appreciated and acknowledged.

Lake/County	Volunteer
Altamont New Effingham Co.	Dustin Lightfoot Vaughn Voelker Kevin Whitten Ray Casselman
Antioch Lake Co.	Jim Golden
Apple Canyon Jo Daviess Co.	Sharon Burmeister Darryle Burmeister Mike Malon
Bangs Lake Co.	Joseph Nichele Ed Lochmayer
Barrington Lake Co.	Val Dyokas Tom McGonigle
Bass Lee Co.	Jerry Corcoran
Beaver Grundy Co.	Barb Arnold Jim Arnold
Beaver Pond DuPage Co.	Gavin Burseth
Benton Franklin Co.	Thomas Appleton Pamela Appleton
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Borah Richland Co.	Patrick Kocher
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Forest Lake Co.	Kathy Paap Cynthia Dane
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Goose McHenry Co.	Ross K. Nelson Jennifer Olson
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Woodhaven Lee Co.	Jerry Corcoran
Woods Creek McHenry Co.	Tom Dunn Chuck Schumann Eric Baillargeon Tom Corvillion Nick Berchicci Zach Hansen
Zurich Lake Co.	Dick Schick Anne Schick

This report represents the coordinated efforts of many individuals. The Illinois Environmental Protection Agency's Lake Program, under the direction of Gregg Good, was responsible for the original design of the Volunteer Lake Monitoring Program (VLMP) and its continued implementation. Two Area-wide Planning Commissions: Chicago Metropolitan Agency for Planning (CMAP) and Greater Egypt Regional Planning and Development Commission (GERPDC), along with Lake County Health Department (LCHD), were responsible for program administration in their regions of the state.

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Acronyms and Abbreviations

AIS	Aquatic Invasive Species
ALU	Aquatic Life Use
AQU	Aesthetic Quality Use
CHL-*a*	Chlorophyll-*a*
CMAP	Chicago Metropolitan Agency for Planning
DO	Dissolved Oxygen
GERPDC	Greater Egypt Regional Planning and Development Commission
GPS	Global Positioning System
ICLP	Illinois Clean Lakes Program
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
LCHD	Lake County Health Department
mg/L	Milligrams per Liter
ml	Milliliter
NPS	Non-point Source
NVSS	Non-volatile Suspended Solids
PLWIP	Priority Lake and Watershed Implementation Program
RfLA	Request for Lab Analysis
SD	Secchi Depth
SPU	Standard Platinum-Cobalt Units
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TN:TP	Total Nitrogen to Total Phosphorus ratio
TP	Total Phosphorus
TSI	Trophic State Index
TSI^{CHL}	TSI for Chlorophyll-*a*
TSI^{SD}	TSI for Secchi Depth
TSI^{TN}	TSI for Total Nitrogen
TSI^{TP}	TSI for Total Phosphorus
TSS	Total Suspended Solids
ug/L	Microgram per Liter
VLMP	Volunteer Lake Monitoring Program
VSS	Volatile Suspended Solids

Program Objectives

1. *Increase citizen knowledge of the factors that affect lake quality in order to provide a better understanding of lake/watershed ecosystems and promote informed decision making;*
2. *Encourage development and implementation of sound lake protection and management plans;*
3. *Encourage local involvement in problem solving by promoting self-reliance;*
4. *Enlist and develop local "grass roots" support and foster cooperation among citizen, organizations, and various units of government;*
5. *Gather fundamental information on Illinois lakes: with this information, current water quality can be determined as well as (with historical data) long term trends;*
6. *Provide a historic data baseline to document water quality impacts and support lake management decision-making; and*
7. *Provide an initial screening tool for guiding the implementation of lake protection/restoration techniques and framework for a technical assistance program.*

Background

There are 3,041 lakes with surface areas of six acres or more in Illinois. Approximately 75 percent of these lakes are artificially constructed (includes impoundments and quarries), 23 percent are river backwaters, and the remaining 2 percent are of glacial origin. In addition to being valuable recreational and ecological resources, these lakes serve as potable, industrial, and agricultural water supplies; as cooling water sources; and as flood control structures.

Physical Characteristics

The physical characteristics of lakes are mainly established during formation. G.E. Hutchinson, in his *A Treatise on Limnology* (1957), described 76 different ways to form lakes. In this report, we will limit our look to four generalized types; glacial lakes, backwater lakes, impoundments, and quarry lakes. Each of these categories can be broken down into many subcategories (not within the scope of this report); however, this report will present data using these categories.

Glacial Lakes

Glaciers formed lake basins by gouging holes in loose soil or soft bedrock, depositing material across stream beds, or leaving buried chunks of ice that later melted to leave lake basins; scour lakes (Lake Michigan), chain of lakes on an outwash plain divided by moraines (Bluff, Catherine, Channel, Fox, Grass, Marie, Nippersink, Pistakee, Petite, and Redhead lakes along the Fox River) and kettle lakes (Grays Lake in Grayslake, Lake County), respectively.

Backwater Lakes

Erosion and deposition of rivers can form lakes, such as meandering rivers forming oxbow lakes. Rivers never follow the same path over extended periods of time and oxbow lakes are formed by the isolated sections created when rivers change direction and cut new channels. Horseshoe Lake near Granite City is a good example of an oxbow lake. Lakes can be formed from river side channels, convergence of several side channels, or connected backwater off-shoots fed by river or streams. These backwaters may be continually fed or intermittently flooded throughout the yearly cycle. For purposes of this report, we will use riverine to group these river associated lakes.

Impoundment Lakes

Humans have created reservoirs (artificial lakes) by damming rivers and streams. Carlyle of Fayette County (26,000 acres), Rend of Franklin County (18,000 acres), Springfield of Sangamon County (4,260 acres), Mattoon of Coles, Cumberland and Shelby Counties (1,050 acres), Apple Canyon (450 acres) and Galena (225 acres) of Jo Daviess County are all examples of impoundment lakes.

Quarry Lakes

Quarries and abandoned excavation sites may fill with water and become lakes, as well. Examples include: Sunset of Champaign County (89 acres, sand & gravel quarry), Johnson of Peoria County (170 acres, coal strip mine), and Independence Grove of Lake County (119 acres, borrow pit).

Lakes constantly undergo evolutionary change, reflected in changes occurring in their watersheds. Most lakes will eventually fill in with the remains of lake organisms as well as silt and soil washed in by floods and streams. These gradual changes in the physical and chemical components of a lake affect the development and succession of plant and animal communities. This natural process takes thousands of years. Human activities, however, can dramatically change lakes, for better or worse, in just a few years.

Lakes serve as traps for materials generated within their watershed (drainage basin). The trapped material generally impairs water quality and may severely impact beneficial uses and significantly shorten the life of the lake. Suspended and deposited sediments can cause serious use impairment problems. Excessive macrophyte (aquatic plant) growth and/or algal blooms often result from the addition of nutrients such as nitrogen and phosphorus. An overabundance of plant life may tend to limit recreational and public water supply usage. Lakes may also collect heavy metal and organic contamination from urban, industrial, and agricultural sources. Dissolved oxygen deficiencies may limit desirable biological habitat, or result in taste and odor problems for public water supplies.

Water Characteristics and Lakes

Water is an invaluable substance with unique characteristics. It is less dense as a solid than as a liquid. While most substances contract when they solidify, water expands. When water is above 39° Fahrenheit (4° Celsius) it behaves like other liquids; it expands as it warms and contracts when it cools. Water starts to freeze when the temperature approaches 32° Fahrenheit (0° Celsius). As the temperature reaches 32° Fahrenheit the water molecules spread apart to lock into a crystalline lattice.

Ice forms and floats on top of a lake when the surface temperature in the lake reaches 32° Fahrenheit. The ice becomes an insulating layer on the surface of the lake; it reduces heat loss from the water below and enables life to continue in the lake. When ice absorbs enough heat for its temperature to increase above 32° Fahrenheit, crystalline lattice of ice is broken and water molecules slip closer together. If ice sank, lakes would be packed from the bottom up with ice, and many of them would not be able to thaw out in spring and summer, since the energy from the air and the sunlight does not penetrate very far.

Water's density increases to a maximum at 39.16° Fahrenheit (3.98° Celsius). Therefore, in lakes, warmer waters are always found on top of cooler waters producing layers of water called strata. This is typical of a lake that is stratified during the summer. In winter, however, the density differences in water cause a reverse stratification where ice floats on top of warmer waters.

The thermal properties of lakes and the annual circulation event that results is the most influential factor on lake biology and chemistry. As surface water warms up in the spring, it becomes lighter than the cooler, denser water at the bottom. The lake becomes stratified as the surface water continues to warm and the density difference between the surface and bottom waters becomes too great for the wind energy to mix.

As the surface waters cool in the late summer and fall, the temperature difference between the layers are reduced, and mixing becomes easier. With the cooling of the surface, the mixing layer gradually extends downward until the entire water column is again mixed and homogeneous. The destratification process is referred to as fall turnover.

During winter, the lake may undergo stratification once again, this time with the colder, less dense water on the surface (or under the ice) with the warmer and denser water of 39^{o} Fahrenheit on the bottom. When the ice melts and the surface water begins to warm up, the density differences between depths are minimal and the lake again circulates creating spring turnover.

The development of summer stratification varies depending on several factors, including lake depth, wind exposure, and spring temperatures. The lakes in Illinois typically finish with spring turnover by early to mid-May; however, to make sure spring turnover is complete in a specific lake, a temperature profile of the water column should be taken. (Marencik et al, 2010).

Eutrophication

Lakes are temporary features of a landscape. Over tens to many thousands of years, lake basins change in size and depth as a result of climate, movements in the earth's crust, shoreline erosion, and the accumulation of sediment. Eutrophication is the term used to describe this process.

Classical lake succession takes a lake through a series of trophic states. Oligotrophic lakes exhibit low plant nutrients keeping productivity low. The lake water contains oxygen at all depths and deep lakes can support cold water fish, like trout. The water in Oligotrophic lakes is clear. Mesotrophic lakes exhibit moderate plant productivity. The hypolimnion may lack oxygen in summer and only warm water fisheries are supported. Eutrophic lakes exhibit excess nutrients. Blue-green algae dominate during summer and algae scums are probable at times. The hypolimnion also lacks oxygen in summer and poor transparency is normal. Rooted macrophyte problems may be evident. These states normally progress in a linear fashion from oligotrophy to eutrophy. This progression corresponds to a gradual increase in lake productivity. Where this is not the case, it usually stems from cultural eutrophication. Finally, hypereutrophic lakes exhibit algal scums during the summer, few macrophytes, and no oxygen in the hypolimnion. Fish kills are also possible in summer and under winter ice.

Some lakes are naturally eutrophic. They lie in naturally fertile watersheds and therefore have little chance of being anything other than eutrophic. Unless other factors, such as higher turbidity or an increase in the hydraulic flushing rate intervenes, these lakes will have naturally high rates of primary production.

It should be noted that the term "eutrophic" covers a wide variety of lake water quality and usability conditions. Eutrophic lakes can range from very desirable recreational and water supply lakes with excellent warm water fisheries, to lakes with undesirable aesthetics and water use limitations (generally considered hypereutrophic). The goal of Illinois Environmental Protection Agency's Lake Program is to protect, enhance, and restore the quality and usability of Illinois' lake ecosystems. This means preventing conditions where the water quality is degraded to the extent of producing nuisance algal blooms, an overabundance of aquatic plants, deteriorated fish populations, excessive sedimentation, and other problems which limit the lake's intended uses.

Tropic State Index

A lake's ability to support plant and animal life defines its level of productivity, or trophic state. The large amount of water quality data collected by the Volunteer Lake Monitoring Program can be complicated to evaluate. In order to analyze all of the data, it is helpful to use a trophic state index (TSI). A TSI condenses large amounts of water quality data into a single, numerical index. Different values of the index are assigned to different concentrations or values of water quality parameters.

The most widely used and accepted trophic state index was developed by Bob Carlson (1977) and is known as the Carlson TSI. Carlson found statistically significant relationships between summertime total phosphorus, chlorophyll-a, and Secchi disk transparency for numerous lakes. He then developed a mathematical model to describe the relationships between these three parameters, the basis for the Carlson TSI. Using this, a TSI score can be generated by just one of the three measurements. Carlson TSI values range from 1 to 100. Each increase of 10 TSI points (10, 20, 30, etc.) represents a doubling in algal biomass. Data for one parameter can also be used to predict the value of another.

The Carlson TSI is divided into four lake productivity categories: oligotrophic (where water bodies have the lowest level of productivity), mesotrophic (where water bodies have a moderate level of biological productivity), eutrophic (where water bodies have a high level of biological productivity), and hypereutrophic (where water bodies have the highest level of biological productivity). The trophic state of a water body can also affect its use or perceived utility. The productivity of a lake can therefore be assessed with ease using the TSI score for one or more parameters (Figure 13). Mesotrophic lakes, for example, generally have a good balance between water quality and algae/fish production. Eutrophic lakes have less desirable water quality and an overabundance of algae; though fish production is typically high.

Some lakes are exceptions to the Carlson TSI model. The relationship between transparency, chlorophyll-a, and total phosphorus can vary based on factors not observed in Carlson's study lakes. For instance, high concentrations of suspended sediments will cause a decrease in transparency from the predicted value based on total phosphorus and chlorophyll-a concentrations. Heavy predation of algae by zooplankton will cause chlorophyll-a values to decrease from the expected levels based on total phosphorus concentrations.

Carlson's TSI Equations	Where,
$TSI^{SD} = 60 - (14.4)(LN(SD))$	SD = Secchi depth transparency (m)
$TSI^{TP} = 4.15 + (14.42)(LN(TP))$	TP = total phosphorus concentration (mg/L)
$TSI^{CHL} = 30.6 + (9.81)(LN(CHL))$	CHL = chlorophyll-a concentration (ug/L)
$TSI^{TN} = 54.45 + (14.43)(LN(TN))$	TN = total nitrogen concentration (mg/L)

Trophic State	TSI	Secchi Depth (in)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Chlorophyll-*a* (mg/L)
Oligotrophic	Less than 40	Greater than 145	Less than 0.367	Less than 0.012	Less than 2.5
Mesotrophic	40 to 50	79 to 145	0.367 to 0.735	0.012 to 0.025	2.5 to 7.5
Eutrophic	50 to 70	18 to 79	0.735 to 2.938	0.025 to 0.100	7.5 to 55
Hypereutrophic	Greater than 70	Less than 18	Greater than 2.938	Greater than 0.100	Greater than 55

A TSI based on average Secchi transparency for each lake is calculated to classify lakes according to their degree of eutrophication as evidenced by their ability to support plant growth. As originally derived by Carlson, each major division of the index (10, 20, 30, etc.…) represents a theoretical doubling of plant productivity (algae biomass). However, for Illinois lakes, the TSI value also reflects sediment-related turbidity; therefore, the higher the TSI value, the greater impairment the lake likely exhibits from sediment-related turbidity and/or algal growth. Lakes with an average Secchi transparency less than 79 inches (a TSI greater than 50) are classified as eutrophic.

Using the Indices Beyond Classification

This section can become very technical and is not necessary to understanding the basics of the results and discussions presented in this document.

A major strength of TSI is that the interrelationships between variables can be used to identify certain conditions in the lake or reservoir that are related to the factors that limit algal biomass or affect the measured variables. When more than one of the three variables is measured, it is possible that different index values will be obtained. Because the relationships between the variables were originally derived from regression relationships and the correlations were not perfect, some variability between the index values is to be expected. However, in some situations the variation is not random and factors interfering with the empirical relationship can be identified. These deviations of the total phosphorus or the Secchi depth index from the chlorophyll index can be used to identify errors in collection or analysis or real deviations from the "standard" expected values (Carlson 1981). Some possible interpretations of deviations of the index values are given in the table below (updated from Carlson 1983).

Relationship Between TSI Variables	**Conditions**
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as Aphanizomenon flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation; zooplankton grazing or toxics limit algal biomass.

The simplest way to use the index for comparison of variables is to plot the seasonal trends of each of the individual indices. If every TSI value for each variable is similar and tracks each other, then you know that the lake is probably phosphorus limited (TN/TP = 33; Carlson 1992) and that most of the attenuation of light is by algae.

In some lakes, the indices do not correspond throughout the season. In these cases, something very basic must be affecting the relationships between the variables. The problem may be as simple as the data were calculated incorrectly or that a measurement was done in a manner that produced different values. For example, if an extractant other than acetone is used for chlorophyll analysis, a greater amount of chlorophyll might be extracted from each cell, affecting the chlorophyll relationship with the other variables. If a volunteer incorrectly measures Secchi depth, a systematic deviation might also occur.

After methodological errors can be ruled out, remaining systematic seasonal deviations may be caused by interfering factors or non-measured limiting factors. Chlorophyll and Secchi depth indices might rise above the phosphorus index, suggesting that the algae are becoming increasingly phosphorus limited. In other lakes or during the season, the chlorophyll and transparency indices may be close together, but both will fall below the phosphorus curve. This might suggest that the algae are nitrogen-limited or at least limited by some other factor than phosphorus. Intense zooplankton grazing, for example, may cause the chlorophyll and Secchi depth indices to fall below the phosphorus index as the zooplankton remove algal cells from the water or Secchi depth may fall below chlorophyll if the grazers selectively eliminate the smaller cells.

In turbid lakes, it is common to see a close relationship between the total phosphorus TSI and the Secchi depth TSI, while the chlorophyll index falls 10 or 20 units below the others. Clay particles contain phosphorus, and therefore lakes with heavy clay turbidity will have the phosphorus correlated with the clay turbidity, while the algae are neither able to utilize all the phosphorus nor contribute significantly to the light attenuation. This relationship of the variables does not necessarily mean that the algae are limited by light, only that not all the measured phosphorus is being utilized by the algae.

Finally, aquatic biomass productivity is affected by limiting certain nutrients, nitrogen and phosphorus. To apply this method, the water body's limiting nutrient must be determined. The limiting nutrient is the nutrient of lowest concentration that controls plant growth. This nutrient is normally phosphorus or nitrogen and in lakes it is most often phosphorus.

This method calculates a separate component TSI for nitrogen, phosphorus and chlorophyll-a. These components are then combined, as indicated in equations A-C below, to determine the overall TSI. As previously stated, the procedure first calculates separate TSI values (via empirical equations that use the natural logarithm [LN], an exponential function in which the base is 2.71828+) for chlorophyll-a [CHL], total nitrogen [TN] and total phosphorus [TP] sample concentrations, and then combines the values through addition. The calculations are shown in the empirical equations one through five below. These equations calculate the TSI for various nutrient relationships. The result of equation one is used for all calculations. The result of equations two and three are used for nutrient balanced lakes (those where the TN to TP ratio is greater or equal to 14 and less or equal to 30). The result of equation four is used for phosphorus limited lakes (those where the TN to TP ratio is greater 30) and the result of equation five is used for nitrogen limited lakes (those with a TN to TP ratio of less than 14).

1. $TSI^{CHL} = 16.8 + 14.4 \times LN(CHL)$
2. $TSI^{TP} = 18.6 \times (LN(TP \times 1000))-18.4$
3. $TSI^{TN} = 56 + 19 \times LN(TN)$
4. $TSI^{TP2} = 10 \times (2.36 \times LN(TP \times 1000) – 2.38)$
5. $TSI^{TN2} = 10 \times (5.96 + 2.15 \times LN(TN \times .001))$

The final TSI is then determined by averaging the above values based on the limiting nutrient determined for the lake using final equations A-C below.

A. Nutrient-Balanced Lakes (N:P Ratio is 14 to 30): $TSI = (TSI^{CHL} + (TSI^{TN} + TSI^{TP})/2)/2$
B. Phosphorus-Limited Lakes (N:P Ratio is greater than 30): $TSI = (TSI^{CHL} +TSI^{TP2})/2$
C. Nitrogen-Limited Lakes (N:P Ratio is less than 14): $TSI = (TSI^{CHL} + TSI^{TN2})/2$

Volunteer Lake Monitoring Program History

Lakes are important resources that will continue to provide beneficial uses if protective measures are taken. In recognition of this need, the Illinois Environmental Protection Agency (IEPA) initiated the Volunteer Lake Monitoring Program (VLMP) in 1981. This program provides effective public education on lake ecology and management and facilitates local lake and watershed management activities. It also serves to supplement IEPA lake data collection efforts. The VLMP provides for a direct transfer of technical expertise from the state level to the local level and provides a valuable service from the local level back to the state.

Annually, 150 to 200 lakes are sampled by approximately 250 citizen volunteers. The volunteers are primarily lake shore residents, lake owners/managers, members of environmental groups, public water supply personnel, and citizens with interest in a particular lake.

The VLMP has been expanded may times since its inception in 1981. A first expansion included the addition of Water Quality Component in 1985. To participate in this component, selected volunteers are trained to collect water samples. These samples are shipped to the IEPA laboratory for analysis of total and volatile suspended solids (TSS and VSS), total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. These water quality parameters are routinely measured by lake scientists to help determine the general health of a lake ecosystem.

In the spring of 1992, the VLMP expanded to include two new components, Zebra mussel (*Dreissina polymorpha*) sampling and dissolved oxygen and temperature measurements. Zebra mussel sample sites were located near public boat ramps or areas where invasion was likely to occur. Volunteers attached samplers to either an in-place buoy or dock allowing it to hang one foot below the water surface. Volunteers monitored the samplers once a month throughout the sampling season. In 1997 because of cost-effectiveness and potential knowledge derived from a VLMP monitoring effort on Zebra mussels, the program expanded to encompass all lakes participating in the VLMP. A second program expansion was established in 1992 to measure dissolved oxygen (DO) and water temperature.

In June 1995, the Illinois General Assembly passed Conservation 2000, a major natural resources protection bill. This bill provided funding to the IEPA to expand its lake management program activities. In 1996, a portion of the funding was used to initiate a Chlorophyll Monitoring Component for 50 VLMP lakes. Due to its success, the VLMP Chlorophyll Monitoring Component was expanded from 50 to 100 lakes the following year.

Components of the VLMP

<u>**"Secchi Transparency"**</u>

Citizens select a lake to monitor and are then trained to measure water clarity (transparency) using a Secchi disk. The Secchi disk was developed in 1865 by Professor P.A. Secchi for a Vatican-Financed Mediterranean oceanographic expedition. At the time, it was used to determine if a ship could safely pass over a reef without damaging its hull. It has since become a standard piece of equipment for lake scientists.

The modern Secchi disk consists of an eight-inch diameter weighted metal plate painted black and white in alternate quadrants attached to a calibrated rope or tape measure. The disk is lowered into the lake water and the depth at which it is no longer visible is noted. This measurement, call the Secchi disk transparency or Secchi depth, is used to document changes in the transparency of lake water. Typically, three sites are monitored in each lake two times per month from May through October.

Measurements taken with a Secchi disk indicate light penetration into a body of water. Certain factors such as, Microscopic plants and animals (algae and zooplankton), water color, and sediment (silt, clay, and organic matter) can interfere with light penetration and lessen the Secchi disk transparency. Generally, the euphotic (light) zone of the lake is from the surface to two and three times the Secchi depth. In this region of the lake there is enough light penetration to allow plants to survive and produce oxygen by photosynthesis. Lake water below the euphotic zone can be expected to have little or no dissolved oxygen during the summer if the lake is thermally stratified.

Analysis of Secchi disk transparencies provide an indication of the general water quality conditions of the lake, as well as the amount of usable habitat available for fish and other aquatic life. Secchi disk transparency is a quick and easy measurement which integrates many important features of a lake system.

Field Observations

The volunteer also records a series of field observations relating to other important environmental characteristics of the lake, such as water color, suspended algae and sediment, aquatic plants, and odor. Weather conditions on the day of sampling, as well as during the prior 48 hours, are recorded. Recent lake management activities or other factors which could impact the lake are also documented. Field observation data can reveal a great deal of information about a lake.

Combined with field observations, Secchi transparency readings provide an indication of the amount of usable habitat available for fish and other aquatic life, as well as general water quality conditions of the lake. Consistent monitoring and observations throughout the sampling season and over a period of years can help identify lake problems and causes, document water quality trends, and evaluate lake and watershed management strategies.

Aquatic Invasive Species

Aquatic invasive species (AIS) tracking has expanded over the years. AIS are freshwater organisms that spread or are introduced outside their native habitats and cause negative environmental and/or economic impacts. You also may hear AIS called aquatic “exotic,” “nuisance,” or “non-indigenous” species. Unfortunately, more than 85 AIS have been introduced into Illinois. The zebra mussel, Eurasian water milfoil, and silver carp are all examples of invaders that have impacted our state.

Aquatic invaders such as these have been introduced and spread through a variety of activities including those associated with recreational water users, backyard water gardeners, aquarium hobbyists, natural resource professionals, the baitfish industry, and commercial shipping. The Illinois VLMP is partnering with Illinois-Indiana Sea Grant, the Illinois Natural History Survey, and the Midwest Invasive Plant Network to monitor for and help prevent the spread of aquatic invasive species to Illinois lakes.

Some of the AIS on the IEPA’s watch list include:

- **Mollusks:** Zebra mussel, Quagga mussel, New Zealand mud snail, Asian clam
- **Crustaceans:** Rusty crayfish, Spiny water flea, Fishhook water flea, Bloody red shrimp
- **Fish:** Round goby, Bighead & Silver carp (Asian carps), Ruffe, White perch

- **Aquatic Plants:**
  - **Submersed (underwater) plants:** Eurasian water milfoil, Curlyleaf pondweed, Brazilian elodea (Brazilian waterweed), Hydrilla, Indian swampweed, Brittle waternymph (Brittle naiad)
  - **Free-floating plants:** European frogbit, Water hyacinth, Water lettuce
  - **Rooted, floating-leaved plants:** Pond water-starwort, Swamp stone crop, European waterclover, Yellow floating heart, Water chestnut
  - **Emergent (above water) plants:** Purple loosestrife, Flowering rush, Reed manna grass, Parrot feather

Identifying Pollutants

Major pollutants, like sediment, (which turns the water shades of brown or tan) and nutrients that act like fertilizers and promote the growth of aquatic plants and algae (which turn the water green, greenish-brown, blue-green or yellowish) can be detected via volunteer monitoring .

Seasonal differences in transparency are often apparent and can indicate the types and causes of problems in a lake. In the spring, the combination of heavy rainfall and lack of plant cover results in increased soil erosion; the suspended sediment may turn the lake a shade of brown. The more suspended sediment, the browner the water and the shallower the Secchi disk reading will be. Illinois lakes are often brown in the spring and green in the summer. However, the brown pattern may repeat itself with rainfall events throughout the year.

Deep lakes that have small amounts of incoming sediment from rainfall are generally clearer in the spring than shallow lakes. They may remain relatively clear throughout the year or they may exhibit algal blooms. Lakes with suspended sediment problems may show some improvement during the summer, when fewer storm events and the development of crop cover in agricultural watersheds generally results in less soil erosion. These lakes, as well as those that were relatively clear in the spring, may develop nuisance algal blooms during the summer if excessive nutrients are present.

Suspended Solids: Total Suspended Solids (TSS) in the water column is composed of volatile and non-volatile fractions. Volatile Suspended Solids (VSS) are organic in nature (plant and animal material), while non-volatile solids are generally inorganic (mineral, soil material) or organics resistant to volatilization at 500°C and is referred to as Non-Volatile Suspended Solids (NVSS). Computing the percentages of TSS that are volatile or nonvolatile indicates whether turbidity is caused primarily by sediment or algae.

Suspended solids in many Illinois lakes result largely from nonpoint sources such as soil erosion from within a lake's watershed and shoreline areas, as well as algal blooms. In shallow lakes, significant suspended solids and turbidity may result from the suspension of bottom materials from wind action, power boating, and activity of bottom-feeding fish, such as carp. Suspended solids reduce the transparency of water and the depth to which sunlight penetrates. Thus, they reduce the extent of the eutrophic zone and limit photosynthetic production of oxygen, and can thereby restrict the usable fish habitat in the lake.

Nutrients: Nitrogen and phosphorus are the primary nutrients that affect aquatic plant growth. Inorganic forms of nitrogen (nitrate/nitrite and ammonia) are used as nutrients by algae and other aquatic plants. Levels of inorganic compounds above 0.3 mg/L at spring turnover are known to contribute to nuisance algal blooms in summer (Sawyer, 1952).

Nitrate and Nitrite Nitrogen: Higher nitrate/nitrite values are often found in lakes in the Illinois, Sangamon, Kaskaskia and Wabash River basins (see river basin map, Figure 2) because of their typically large, highly agricultural watersheds. This is characteristic of central Illinois artificial impoundments with ditched and tiled agricultural watersheds. High nitrate concentrations are often detected in surface water following fertilizer application and after spring rains. Nitrates can also leach through the soil and into groundwater where they are discharged into spring-fed lakes.

High nitrate and nitrite concentrations are major public health considerations. The Illinois Pollution Control Board (IPCB) Public and Food Processing Water Supply standards require that nitrate concentrations not exceed 10 mg/L and nitrite not exceed 1 mg/L. Higher values are especially dangerous to infants less than six months old because of their susceptibility to methemoglobinemia, "*blue baby syndrome*."

Total Ammonia Nitrogen: Ammonia in fresh water can be extremely toxic to aquatic organisms, while at the same time it is a source of nutrients that promote plant growth. For "General Use" waters, the IPCB specifies that total ammonia nitrogen shall not exceed 15 mg/L, and un-ionized ammonia shall not exceed 0.04 mg/L. Ammonia nitrogen in aquatic systems usually occurs in high(er) concentrations only when dissolved oxygen is low or depleted. The chronic standard concentrations for total ammonia nitrogen (in mg/L) are different depending on pH and temperature. The acute standard is dependent on pH only (see below).

Illinois Total Ammonia Nitrogen Acute Standard by pH

pH	Ammonia (mg/L)	pH	Ammonia (mg/L)	pH	Ammonia (mg/L)
7.6	15.00	8.1	6.95	8.6	2.65
7.7	14.40	8.2	5.73	8.7	2.20
7.8	12.10	8.3	4.71	8.8	1.84
7.9	10.10	8.4	3.88	8.9	1.56
8.0	8.41	8.5	3.20	9.0	1.32

Phosphorus: Phosphorus is an essential nutrient for plant and animal growth. It is a constituent of fertile soils, plants, and protoplasm (the living contents of a cell). It also plays a vital role in energy transfer during cell metabolism. To restrict noxious growth of algae and other aquatic plants, the IPCB established a General Use standard of 0.05 mg/L for total phosphorus (TP) in any lake, or in any stream at the point where it enters a lake. Allum et al (1977) classified oligotrophic lakes as those with TP values below 0.01 mg/L and mesotrophic as those lakes with TP values between 0.01 and 0.02 mg/L. Eutrophic lakes have TP values greater than 0.02 mg/L.

Chloride: Chlorides (Cl-) are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). Sodium chloride is widely used in the production of industrial chemicals such as caustic soda, chlorine, sodium chlorite, and sodium hypochlorite. Sodium chloride, calcium chloride, and magnesium chloride are extensively used in snow and ice control. Potassium chloride is used in the production of fertilizers.

Prior to major settlements in Illinois, Cl- concentrations in most shallow groundwater and rivers and streams were very low, probably < 10 mg/L, and in many cases much lower. The exceptions were areas where natural brines in Paleozoic sedimentary rocks discharged at or near the land surface. There were numerous saline springs that were exploited by Native Americans and early settlers for making salt. There are numerous streams and rivers in Illinois with names such as Salt Creek or Saline Branch, named because of the discharge of saline water in or near these streams. One of the most likely results of increasing Cl- concentrations in surface waters is degradation of aquatic biota.

Chicago, many of its suburbs, and many other cities in Illinois have combined sewer systems, with storm water runoff being collected and treated at WWTPs. A large percentage of road salt runoff in the most urban parts of the Chicago region thus does not enter shallow groundwater but is diverted to streams and rivers in discharge from WWTPs. The rapid transfer of saline snow melt to streams and rivers in Chicago produces very high Cl- concentrations in the winter.

The ALMP program analyzes for Cl- at power plant lakes, mine-impacted lakes, Public Water Supply lakes, and lakes where conductivity readings are above 800 us/cm. Years of ambient and volunteer program data reflect that the highest Cl- levels are indeed in the Chicago and surrounding counties. Therefore, Cl- analysis is now limited in the VLMP to those counties only, since volunteers do not have access to conductivity measuring equipment.

Illinois Water Quality Standards for Total Chloride

Water Use	Guideline (mg Chloride/L)
Drinking water	250
Recreation and Aesthetics	None
Freshwater Aquatic Life	500

Alkalinity

Alkalinity refers to the capability of water to neutralize acid or its buffering capacity. A buffer is a solution (surface water) to which an acid (acid rain) can be added without changing the pH appreciably. It essentially absorbs the excess H+ ions (acid) and protects the water body from fluctuations in pH. In most natural water bodies the buffering system is carbonate-bicarbonate ($CO_2 \Leftrightarrow HCO_3^- \Leftrightarrow CO_3^{2-}$). The presence of calcium carbonate or other compounds such as magnesium carbonate contribute carbonate ions to the buffering system. Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks (limestone) which are mostly $CaCO_3$. If $CaCO_3$ actually accounts for most of the alkalinity, hardness in $CaCO_3$ is equal to alkalinity. Since hard water contains metal carbonates (mostly $CaCO_3$) it is high in alkalinity. Conversely, unless carbonate is associated with sodium or potassium which don't contribute to hardness, soft water usually has low alkalinity and little buffering capacity. So, generally, soft water is much more susceptible to fluctuations in pH from acid rains.

Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Living organisms, especially aquatic life, function best in a pH range of 6.0 to 9.0. Alkalinity is a measure of how much acid can be added to a liquid without causing a large change in pH. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life. For protection of aquatic life the buffering capacity should be at least 20 mg/L.

USGS General guide-lines for classification of water hardness

Classification	As Calcium Carbonate (mg/L $CaCO_3$)
Soft	0 to 60
Moderately Hard	61 to 120
Hard	121 to 180
Very Hard	180 or greater

Chlorophyll: Chlorophyll is a pigment found in all green plants and is responsible for giving them their hue. It is also the chemical which allows plants to carry out photosynthesis (the process plants use to convert sunlight, water and carbon dioxide to oxygen and energy or food). There are many different forms of chlorophyll. Algal chlorophyll is found as three different types. Chlorophyll-a (found in all algae), chlorophyll-b (found in green algae and eulgenoids), and chlorophyll-c (found in diatoms and golden brown algae). By taking a measured sample of lake water and extracting the chlorophyll from the algae cells contained in that sample, monitors can get a good indication of the density of the algal population. The density of the algae population will tell lake scientists if an algal bloom is likely to occur.

When blooms occur, oxygen depletion can occur due to increased respiration of the algae during the night and on cloudy days. Additionally, when a bloom dies off, the decay process can increase the potential for oxygen depletion, in addition to causing taste and odor problems for public water supplies.

The chlorophyll sample is taken at twice the Secchi depth (but no closer than 2 feet off of the bottom) and is filtered by the volunteer. The water quality sample and the chlorophyll samples are then mailed to the IEPA's Springfield laboratory for analysis. All training, equipment, and analysis are free of charge to the volunteers.

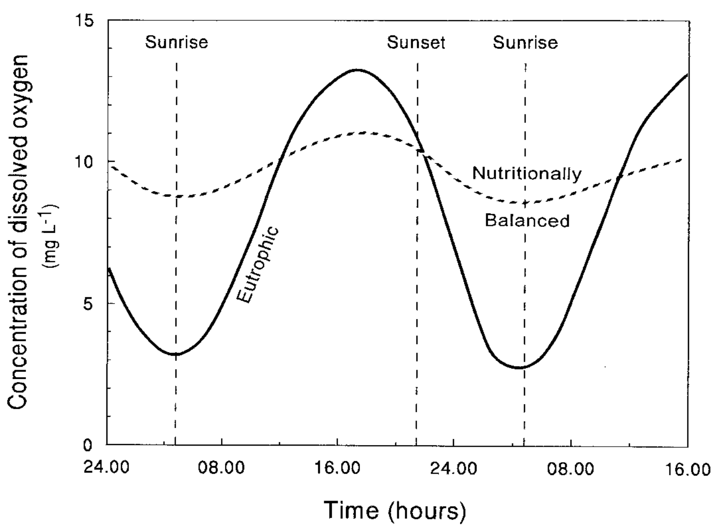
Dissolved Oxygen/Temperature

These two water quality measurements play important roles in the overall health of lakes. Most living organisms need oxygen to survive. So it is important to know how much and at what depth dissolved oxygen is available to these organisms. The amount of oxygen in a lake is dependent on lake water temperature and on lake stratification. Low oxygen levels often occur during summer and winter stratification. During the summer in Illinois' stratified lakes, the top layer is warm and oxygenated (epilimnion), while the bottom waters are very low in oxygen and cooler (hypolimnion).

Oxygen can enter the water column in several ways. The most common are through photosynthesis of aquatic plants and algae, as well as through diffusion of oxygen entering the lake from the atmosphere. Oxygen can also enter the lake via water from inflowing tributaries.

The amount of oxygen that can be dissolved in water is determined by the water's temperature. Cooler water can hold more oxygen than warmer water. Often, the amount of oxygen in water is reported as percent saturation. During an algal bloom, the algae can put more oxygen into the water than the water can normally hold; this is called super-saturation. The percent saturation is calculated as a ratio of the lake's actual dissolved oxygen concentration and the maximum concentration possible under saturated conditions. During an algal bloom, the percent saturation may exceed 200 percent. Conversely, the mass dying of algae and/or macrophytes can cause a depletion of dissolved oxygen as organisms that use oxygen feed on dead material.

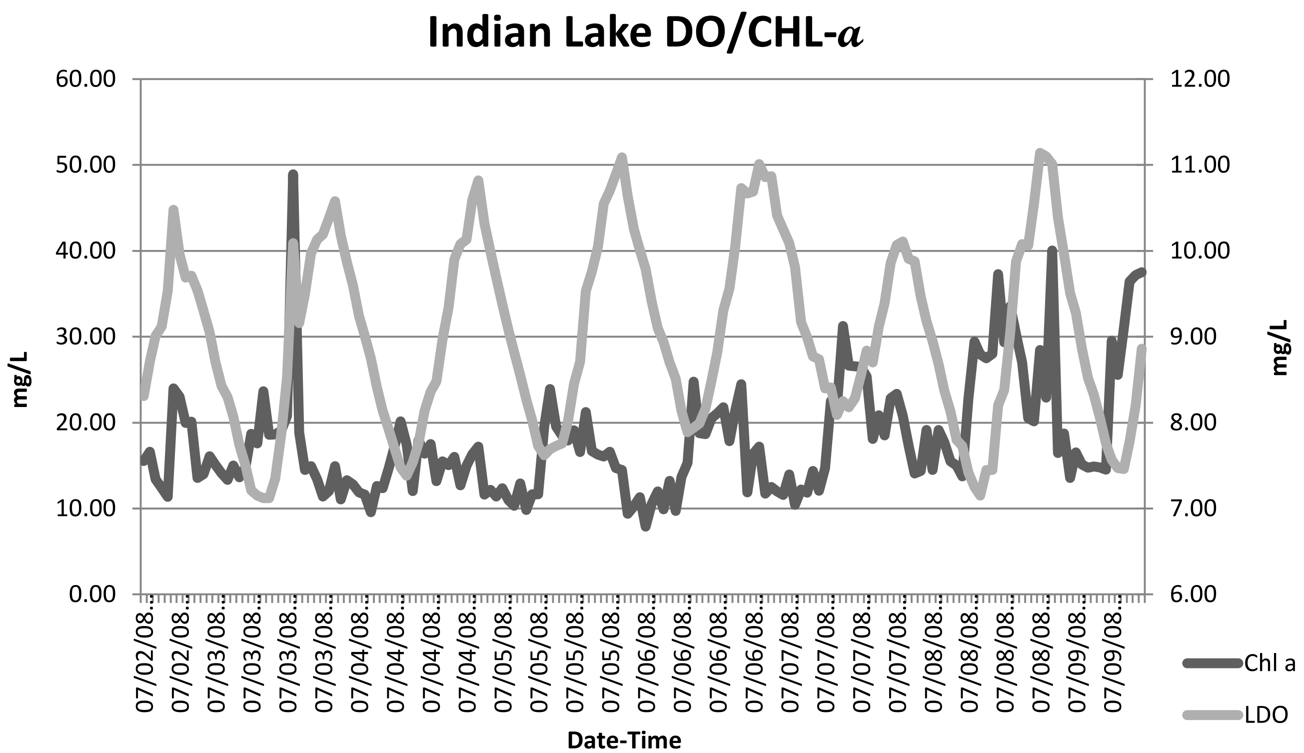
SUPER-SATURATION AND DEPLETION GRAPH (Wetzel 2001)



The graph depicts the dramatic difference between a nutritionally balanced lake and a eutrophic lake. Dissolved oxygen levels that drop below a certain threshold may cause a "fish kill," depending on fish species present.

A study by John Kanzia, Environmental Quality Manager of the Chicago Zoological Society and Brookfield Zoo, plots the concentrations of dissolved oxygen and chlorophyll-a over a period of eight (8) days in early July of 2008. These data were collected at Indian Lake of Cook County with a Hydrolab DS5X 44813.

Temperature is indicative of water density and therefore drives the stratification process. By knowing the temperature of the water at different depths, potential oxygen depletions can be predicted. During summer stratification, warm water is the least dense and is found near the surface. Cold water is denser (unless frozen) and is on the bottom. Between these two layers is the thermocline, an area of rapid temperature change. The thermocline acts as a barrier that does not allow mixing of oxygen from the epilimnion to the hypolimnion.



DIURNAL CYLCE OF DISSOLVED OXYGEN AND Chlorophyll-a ON INDIAN LAKE, ILLINOIS (Kanzia 2008)

Summary of VLMP Tiered Approach for 2014

Tier Level	Tier I	Tier II	Tier III
Fundamental Activities	Secchi Monitoring Form	Water Quality Sampling & Tier I	Expanded Water Quality Sampling, DO/Temp Readings, and Tier I
Lake Requirements	Any Lake or Pond	Any Lake or Pond	Lakes greater than 20 acres
Purpose for Generated Data	Education & Generation of Water Quality Trends	Expanded Education, Baseline Water Quality Indicators & Use Assessments	Expanded Education, Water Quality Indicators, Use Assessments, & TMDL Development
Monitoring Expectations	Twice per month May - October	As Tier I with water collection @ site 1, once per month, May - August	As Tier I with water collection @ multiple sites & depths, once per month, May – August & October
Parameters	Secchi transparency, aquatic plant coverage, apparent color, water level, weather conditions, 48 hour rainfall, aquatic invasive species tracking, & notes	As Tier I & water collection for analysis of Ammonia, Nitrate/Nitrite, TKN, TSS, VSS, TP, Chloride, Alkalinity and Chlorophyll	As Tier I, Tier II water collection at multiple sites and depths, and dissolved oxygen/temperature profile readings at all sites.
Volunteer Attributes	No experience needed, access to boat and anchor, & personal flotation device	Previous year of consistent Tier I participation	Previous year of consistent Tier I participation and at least one year of Tier II experience
Training	Personal training at volunteer’s lake	Personal training or centralized training	Personal training and audit activities at volunteer’s lake

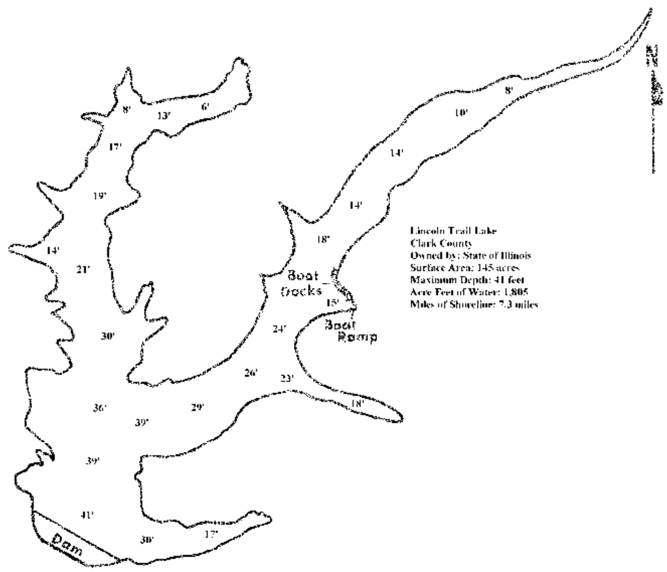
Methods and Procedures

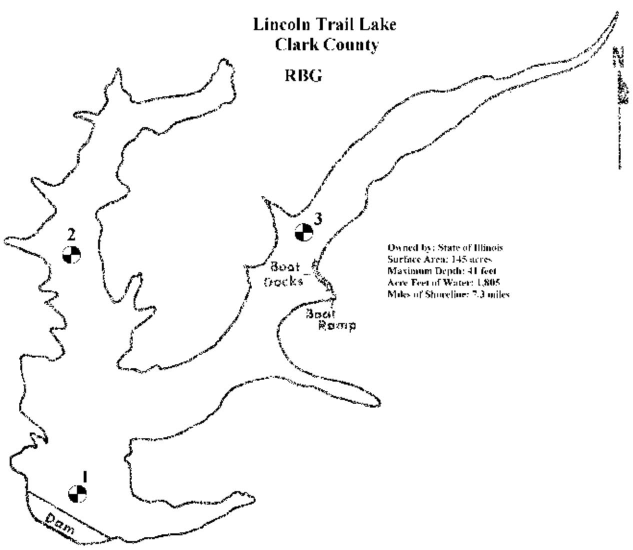
Volunteer Education

A session at the Illinois Lake Management Association's Annual Conference is designated as the Volunteer Lake Monitoring Program Session. Session participants receive information about other volunteer programs and an update on the VLMP for the upcoming sampling season. Volunteers also receive a VLMP newsletter. These newsletters contain reminders for the volunteers regarding VLMP, as well as educational information on lake conditions, management, and monitoring.

Training Volunteers

Training of new volunteers, "refresher" training for returning volunteers, and expanded monitoring training are conducted by staff coordinators from IEPA's Lake Program, as well as from Regional Coordinators. In all cases, this training takes place at the volunteer's lake. During the training sessions, the coordinator uses the volunteer's boat to visit each sampling site, whereupon the volunteer is instructed in the proper sampling procedures.





Basic Monitoring Program

Volunteers typically take lake water transparency readings with a Secchi disk at three designated sites, generally twice a month from May 1 through October 31. The sites are chosen after a review of the lake's physical statistics including a bathymetric map, location and size of inlets and outlets, and any structures or features affecting the lake, such as, farms, residential properties, commercial or industrial properties and old dam or infrastructure with the confines of the lake bed. Site one is typically the deepest part of the lake. In impoundment lakes, that is most often near the dam.

Two or more additional sites are identified in the inlets (fingers) for the lake, in channels deep enough for volunteers to reach by boat. A site map is generated by the program personnel that includes the general site locations, Global Positioning System (GPS) coordinates (if available), and a unique site code identifying the lake.

Basic Monitoring Procedures

The volunteer proceeds to a site using a lake map. The order for monitoring the lake sites is not specific. Locations are located specifically by either using "sight lines" (aligning 2 sets of landmarks on shore) or by GPS coordinates. After reaching the monitoring site, the volunteer carefully lowers the anchor over the side of the boat until it reaches the lake bottom, letting out plenty of anchor line so that the boat drifts away from any sediment disturbed by the anchor.

The volunteer removes any sunglasses, hat or object which may obstruct a clear view of the Secchi disk. The Secchi disk is then slowly lowered into the water until it can no longer be seen. At the point where the volunteer loses sight of the disk, the rope or survey tape is marked at the water level with a clothespin. The Secchi disk is then lowered about 1 to 2 more feet into the water, before slowly being raised towards the water surface. When the disk reappears, the line is again marked by pinching the rope or survey tape at the water level with the fingers. The rope/survey tape and Secchi disk are brought back into the boat, being careful not to release the "pinching" fingers. A loop is formed between the clothespin and the pinching fingers, sliding the clothespin to the center (the top) of the loop. This marks the average of the two transparency readings. The number of inches between the disk and the clothespin, to the closest inch, is recorded on the Secchi Monitoring Form, along with the time (in 24-hour format) that the measurement was taken.

Sometimes, the "true" Secchi disk transparency can't be measured because either: the disk reached the lake bottom and could still be seen or the disk was lost from view because it "disappeared" into dense growth of rooted aquatic plants. Sometimes moving a few feet will permit the Secchi disk to be observed through the aquatic plants; however, this situation cannot always be avoided. The Secchi Monitoring Form is annotated to reflect these two potential situations. Secchi disk transparency reading is recorded regardless of these situations.

Volunteers also record apparent water color at each location. The water color is determined by lowering the Secchi disk (on the shaded side of the boat) to one-half (½) the Secchi transparency. The Color Chart is held just above the surface of the water near one of the disk's white quadrants, compared to the color of the white quadrant with the various colors on the standardized color chart, and the corresponding number is recorded on the Secchi Monitoring Form. If no exact match exists, the color number that is the closest match or a 20 to represent "other" is recorded. If choosing other, the volunteer provides their observations in "Additional Observations." If the Secchi transparency was limited by either reaching the lake bed or plant growth, a color reading is not taken (a dash or "n/a" for color on the Secchi Monitoring Form is recorded).

- *If collecting water samples, chlorophyll samples, and/or recording dissolved oxygen/temperature measurements at this site as part of the expanded program, the volunteer stops here and proceeds to the expanded program methods. When completed with the expanded program, they return to finish the basic monitoring.*

To complete basic monitoring, the volunteer measures the site's total water depth by lowering the Secchi disk all the way to the bottom of the lake. They make sure the rope or survey tape is vertical before placing the clothespin on the rope/survey tape at the water level. The Secchi disk is brought back up into the boat. The volunteer then determines the site's total depth and records this depth to the nearest half-foot. Alternately, a volunteer may use a depth sounder. Next, they pull up the anchor line in preparation to leave.

Before proceeding to the next site, they volunteer indicates the relative amount of aquatic plants growing in the immediate vicinity of the monitoring site by circling the appropriate number (0-4) on the Secchi Monitoring Form. The scale is as follows:

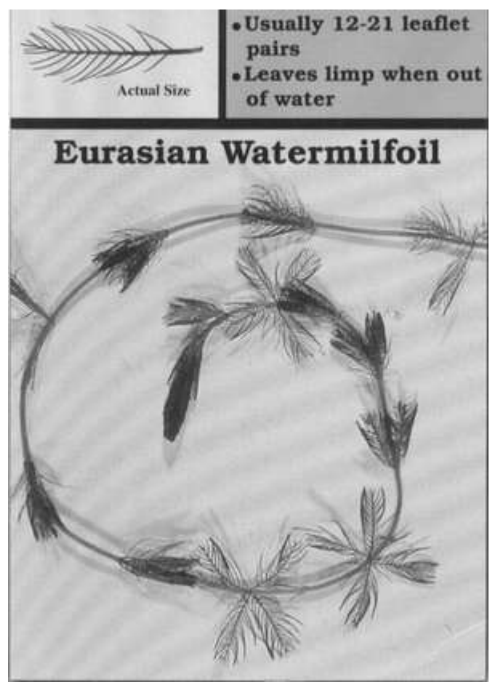
0 = None: no floating-leaved aquatic plants (e.g., lily pads) or submersed (underwater) plants visible or pulled up with the Secchi disk or anchor.

1 = Minimal: only a very few floating-leaved plants or submersed plants visible (or if not visible, a couple/few plant strands might be pulled up with the anchor). Submersed plant growth may be well below the water surface and may or may not be visible as you look into the water.

2 = Slight: a small amount of floating-leaved plants and/or submerged plants visible (or if not visible, a clump of plants might be pulled up with the anchor). Submersed plant growth may be well below the water surface and may or may not be visible as you look into the water.

3 = Moderate: extensive but not complete coverage by floating-leaved and/or submersed plants. Submersed plants would be visible, growing close to the water surface. Boaters and/or swimmers could probably still use the area.

4 = Substantial: complete coverage of the water surface by floating-leaved plants and/or submersed plants that have grown to the water surface. Boaters and/or swimmers would have a difficult time using this area.



The volunteer repeats these sampling procedures for each monitoring site. If a search for AIS is conducted, it is noted in the "Lake/Watershed Management" section of the Secchi Monitoring Form. More details about AIS monitoring are provided on the following pages. The volunteer indicates on the Secchi Monitoring Form that a AIS search is conducted; what areas of the lake are checked; what objects are inspected, if applicable, in those areas (e.g., multi-plate or concrete block sampler, dock posts, buoys, riprap, etc.); and whether or not any AIS at each of those locations were found.

<u>Aquatic Invasive Species Tracking</u>

All VLMP volunteers are requested to participate in the AIS monitoring effort. Provided in the Training Manual is a set of AIS "WATCH" cards that provide a photo, sketch, description, and identification tips for several invasive fish, mollusk, crustacean, and aquatic plant species. Also provided is a "New Aquatic Invasive Plants" identification sheet with photos and descriptions of several aquatic invasive plants, which have been documented in the Midwest. The participating volunteer reviews each

WATCH card and the New Aquatic Invasive Plants sheet, and keeps an eye out for these and any aquatic invaders.

If a volunteer finds—or suspects they have found—any aquatic invasive species, they make note of exactly where it was found, take photos and collect and preserve some specimens if possible, according to the tips provided for the various species in their manual. They then contact their Regional VLMP Coordinator or the Statewide VLMP Coordinator for further instructions about sending specimens for identification.


Eurasian Ruffe

Expanded Monitoring Program

In addition to collecting the information for the Basic Program, volunteers involved in Tier II or III, special projects or involved in the Illinois Clean Lakes Program, collect water samples analyzed by the IEPA laboratory. These samples (consisting of a 500 mL preserved bottle, a 500 mL unpreserved bottle, and a 1L preserved amber bottle) are collected and analyzed for nutrients, suspended solids, alkalinity, chlorides and chlorophyll. A nutrient and suspended solid sample is collected at one foot and (if selected) at two feet from the bottom. A chlorophyll sample is collected from the lake surface to twice the Secchi depth. Due to light penetration, this is the region of the lake where plant life is expected to be present. The volunteer then filters the chlorophyll sample and the filter is sent to the laboratory.

- **500 mL preserved sample** is analyzed for ammonia, total Kjeldahl nitrogen, total nitrite + nitrate nitrogen, and total phosphorus.
- **500 mL sample (without preservative)** is analyzed for TSS, VSS, chloride (at selected lakes), and alkalinity.
- **Chlorophyll filter sample** is analyzed for chlorophyll-*a*, chlorophyll-*b*, chlorophyll-*c* and pheophytin.

General Sample Handling

The collection frequency of the expanded monitoring program depends on tier level. Tier II collects water samples once each month from May through August while Tier III also collects a sample in October as well. During the same trip, a basic "Secchi transparency monitoring" is also conducted. Water chemistry and chlorophyll samples are collected on a Sunday, Monday, Tuesday, or Wednesday because there is a short holding time in the lab on the samples. Therefore, the volunteer plans ahead so that the samples are properly chilled and shipped in a timely manner. The samples are shipped the same day they are collected (if that is not possible, ship them no later than the next day). Wednesday is the

last day during the week samples are shipped to ensure the samples will arrive and are checked in at the laboratory before the following weekend.

To ensure that water samples arrive at the lab within the acceptable temperature range, the volunteer ensures that all sample bottles are kept in a cooler and surrounded by ice until it is time to pack and ship the samples.

More ice is added to the cooler if needed after returning from a sampling trip. If not shipping the samples until the following day, the bottles are kept upright and surrounded by ice in a cooler. The following day, the sample cooler is packed with blue ice packs and shipped. Ice packs are fully frozen (in a freezer for at least 24 hours) and sample bottles remain surrounded by ice in a cooler for at least 1 hour in order to fully chill them prior to packing and shipping.

If filtering water for chlorophyll analysis, the volunteer freezes the foil-wrapped filter(s) in the plastic reclosing bag immediately after filtering. After securing each baggie containing a foil packet to a frozen ice pack using rubber bands, the volunteer places the ice pack(s) with the attached baggie(s) into a freezer until they are ready to pack and ship them to the lab. If they do not have access to a freezer, the baggie(s) are sandwiched between two ice packs and kept in a cooler and out of the sun.

Water Quality Sampling Procedures

A “rinse” and “sample collection” side of the boat is established and the volunteers do not collect samples near the anchor line. They rinse their hands and forearms briskly in the water on the “rinse” side of the boat opposite from where you will sample. The volunteer rinses the half-gallon water collection bottle on the “rinse” side of the boat by immersing the half-gallon bottle, with the cap on, into the water. The cap is removed while the bottle is under water using their other hand. While keeping this hand away from the bottle opening, they allow the bottle to fill about half way, the replace the cap while the bottle is still under water. The bottle is raised out of the water, the contents shaken, the cap removed, the water discarded on the “rinse” side of the boat, and the cap replaced.

Next, the volunteer proceeds to collect the water sample by moving to the “sample collection” side of the boat. The half-gallon bottle is immersed, with the cap on, down into the lake about 1 foot deep (up to their elbow) and the cap removed under water with their other hand, while keeping this hand away from the bottle opening and allowing the bottle to fill completely. The cap is replaced while the collection bottle is still under water before bringing the collection bottle up into the boat. The half-gallon collection bottle is gently inverted a few times so that the water is well mixed. The cap is removed from the half gallon bottle and set it aside with its inside portion facing up.

Next the volunteer takes the two sample bottles (1 preserved, 1 unpreserved) out of the cooler and keeps the bottles upright. Taking the preserved bottle first, they unscrew its cap and set the cap aside with its inside portion facing up. They are careful to keep the inside of the cap from getting contaminated. If the cap does get soiled, they can rinse the cap in the lake on the “rinse” side of the boat.

The water is slowly poured from the half-gallon collection bottle into the preserved sample bottle, then filled to just under its shoulder. The volunteer is careful not to overfill the preserved bottle, since it contains an acid preservative. The preserved sample bottle is recapped tightly and gently rotated and inverted to ensure the preservative is well-mixed with the sample water. The volunteer follows the same procedure to fill the unpreserved sample bottle. Both the preserved and unpreserved sample bottles are filled from the same half-gallon water collection.

If overfilled, the preserved bottle is mark with a big “X” across its label and set aside for later disposal. The appropriate SAMPLE ID is written on a new preserved bottle. The lake water that’s still in the half-gallon collection bottle is poured out on the “rinse” side of the boat, then resample as described above.

The two sample bottles are immediately placed into a cooler with ice. The bottles are pushed into the ice so they are upright and surrounded by ice. The lid is tightly shut, so sunlight cannot reach the samples. Any remaining water in the half-gallon collection bottle is discarded on the “rinse” side of the boat.

Chlorophyll Sampling Procedures

The volunteer checks the water depth again using the handheld depth sounder. Or in cases where a depth sounder is unavailable, a volunteer uses a Secchi disk assembly to measure the depth and left on bottom until water sample is taken to reduce pulling sediments up from the bottom. (The chlorophyll sampling depth is twice the Secchi transparency, to the nearest foot, unless the lake is not deep enough at the monitoring site or if aquatic plants might interfere with sample collection. In these cases, the depth is reduced to 2 feet from the bottom of the lake or to a depth that does not touch plant growth.) In all cases, the volunteer collects the chlorophyll sample to the nearest foot. They also make sure to record the chlorophyll sample collection depth on the Secchi Monitoring Form and chlorophyll lab sheet.

To collect a chlorophyll water sample, the volunteer uses a clothespin and places it at the predetermined depth on the weighted bottle sampler rope. A half-gallon chlorophyll collection bottle is placed into the weighted bottle sampler and the bottle cap is removed. They rinse the chlorophyll collection bottle by lowering the bottle and sampler a foot or two into the lake on the “rinse” side of the boat. If there is a surface scum, it is broken up by “bouncing” the weighted bottle sampler on the water surface a few times. The bottle is allowed to fill about half way, pulled back up, shaken, and the rinse water is discard into the lake on the rinse side.

If the chlorophyll sampling depth is 12 feet or more, a special cap with a hole drilled in the center is used. This special cap slows down the rate at which the bottle fills, allowing the volunteer to collect a more precise sample. The volunteer moves to the “sample collection” side of the boat. If there is a surface scum, it is broken up by “bouncing” the weighted bottle sampler on the water surface a few times. In one continuous motion, the volunteer lowers the bottle at a steady pace to the depth marked by the clothespin, then raised at a steady rate. The volunteer does not pause or stop during the process. The volunteer may find it necessary to lower and raise the bottle more than once. They continue at a steady lowering and rising pace until the bottle is one-half (1/2) to two-thirds (2/3) full. If the collection bottle is completely (or even nearly completely) full after it is pull up, the water is discarded on the “rinse” side of the boat and the collection is started over. As they lower and raise the weighted bottle sampler, they never let it touch the lake bottom or rub against aquatic plants. The weighted bottle sampler is brought into the boat and the solid cap is placed on the half-gallon bottle and tightened, then removed from the sampler. The half-gallon bottle is gently inverted several times to ensure the water is well mixed.

The 1 Liter preserved amber bottle is taken out of the cooler, its cap removed and set aside with its inside facing up. The half-gallon bottle's cap is removed in the same manner. The volunteer slowly pours the water from the half-gallon bottle into the amber bottle. The amber bottle is filled to or near its shoulder, being careful not to overfill the amber sample bottle as it contains a powdered preservative (magnesium carbonate, $MgCO_3$) that can be washed out if the bottle is overfilled. If it is overfilled, the amber bottle is marked with a big "X" on its side and set it aside for later disposal. A new amber bottle is used. Any lake water still in the half-gallon collection bottle is poured out on the "rinse" side of the boat, then the collection procedures are repeated as mentioned above. The amber bottle tightly closed and gently rotated and inverted several times to ensure the preservative is well mixed. It is then placed into a cooler on ice, closing the lid of the cooler to ensure sunlight does not reach the sample. Any remaining water is discarded in the half-gallon collection bottle on the "rinse" side of the boat.

<u>Chlorophyll Filtering Procedures</u>

After the volunteer gets back to shore they need to immediately filter their chlorophyll sample(s), preferably in their home, office, or a nearby building. If this is not feasible, they pick a comfortable location that is in the shade and out of the wind. They also make sure they have all their chlorophyll filtering equipment and supplies handy.

The plastic tubing is attached to the hand pump and to the spout on the plastic flask, making sure to push the tubing over the two raised rings on the spout to make a tight seal. Using the wash bottle or under a faucet, the volunteer rinses the lower portion of the magnetic filter funnel and pushes the stopper end into the top of the plastic flask. Wetting the stopper first helps to make a tight seal. They volunteer ensures that they do not touch the filter screen with their fingers. When inserting the stopper into the filter flask, they push down on the stopper itself, since pushing down on top of the filter base could break the instrument. Using the tweezers, the volunteer carefully removes one filter from the reclosing bag of filters and places the filter exactly in the center of the black filter screen. Again, the volunteer does not touch the filter or the filter screen with their fingers. They might need to squirt a small amount of fresh tap water onto the filter to ensure that the entire filter becomes moistened and stable. If they need to move the filter slightly to center it on the screen, they do so by gently and carefully using the tweezers to grip the edge of the filter and reposition it. If the filter tears, punctures, or creases, they use a new filter. The tinted plastic funnel cup is rinsed with fresh tap water and carefully aligned on the funnel cup on top of the filter base. They volunteer ensures that the filter does not move, and that the funnel cup doesn't come in contact with the middle area of the filter. The graduated cone is rinsed with fresh tap water. The volunteer takes the chlorophyll sample bottle out of the cooler and mixes the sample gently by turning it upside down several times. The graduated cone is filled with sample water exactly to the 500 ml mark.

To begin filtering, the volunteer pours some of the water from the graduated cone into the funnel cup. They squeeze the hand pump to create a vacuum suction. The volunteer does not apply more than "15 inches" of vacuum pressure as measured on the outer scale of the pump's gauge. When the vacuum pressure reaches “10 inches” as read on the gauge’s outer scale, they stop adding much more sample water to filter, if any. As the filtering slows, they add smaller amounts of water. All of the sample water that they pour into the funnel cup is filtered. If filtering really slows down, they are patient and let the water drip through slowly, being careful not to exceed 15 inches of vacuum pressure. If the filter becomes fully clogged and any water left in the funnel cup cannot pass through, they will start the entire process over.

When they're done filtering the sample, they use the squirt bottle and "wash down" the sides of the funnel cup with small amounts of water to wash down any algal cells adhering to the side of the vessel. The volunteer applies additional vacuum suction as needed to completely pull the "wash water" through the filter, making note of volume filtered. When the vacuum suction has pulled all the wash water through and the filter looks relatively "dry," they release the vacuum pressure by pulling on the hand pump’s trigger. Next, they carefully push the rubber stopper slightly off the flask to release any remaining vacuum seal. While holding onto the filter base with one hand, they carefully lift the funnel cup off, up, and away from the filter base with their other hand.

Without removing the filter from the screen, the volunteer uses the tweezers to fold the filter in half so that the algae are on the inside. They use the "modified" paper clip to help hold the filter in place while they gently fold it. Again, they do not touch the filter with their fingers and the tweezers and paper clip never touch the algae covered portion of the filter. Using the tweezers, they fold the filter in half again and remove the filter from the filter screen with the tweezers placing the filter on a piece of aluminum foil. Folding each edge of the aluminum foil around the filter to form a closed packet, the volunteer places the packet in a labeled small sample bag and rubber-band the packet to an ice pack and place it in the freezer or a cooler until shipping. The label is marked with sample identification and volume of filtered chlorophyll sample in milliliters.

<u>Dissolved Oxygen/Temperature Profiles Procedures</u>

The volunteer calibrates the dissolved oxygen and temperature (DO/temp) meter. At each site location, they turn on the DO/temp meter and ensure the cable is securely attached to the meter. They check the water depth again using the handheld depth sounder or use a Secchi disk assembly. The volunteer writes in the required information at the top of the “Dissolved Oxygen/Temperature Profile” data form: unique station code, lake name and county, volunteer name(s), date (mm/dd/yyyy), time (hh:mm), meter brand/model (e.g., Hach HQ30d, Hydrolab Quanta, YSI 550A), IEPA case/meter #, barometer reading, and comments. The zero, one foot, and subsequent two foot intervals are pre-printed on the form to forty-nine (49) feet. The volunteer circles the interval which is at least two feet above the recorded lake bottom.

They place the probe into the lake, making sure the tip of the probe is under the water surface by immersing the probe to the top of the protective shroud’s locking ring. (This is the “0” depth.) They press the “Read” button. The display indicates a stabilized reading when the meter beeps and a padlock icon appears in the upper left corner of the screen. The volunteer records the displayed DO and temperature readings on the data form, rounding to the nearest tenth. The DO is displayed in mg/L (milligrams per liter), and the temperature is in °C (degrees Celsius).

They repeat reading and stabilizing after lowering the probe to the 1 foot depth, and then to every other foot thereafter, down to 2 feet above the lake bottom. After recording the final DO/temperature measurement at each monitoring site, they turn off the meter to conserve battery power.

Data Handling

After collecting the Secchi depth and other information and entering that data into an Online Lakes Database, volunteers return the completed monitoring forms to the appropriate coordinator after each sampling trip, and the data is validated for accuracy in the database or entered into the data management system (if the volunteer does not have web access). This system serves to check in monitoring forms, enter Secchi and other qualitative data, track volunteer participation, produce graphical and tabular outputs and provide volunteers and the public with immediate access to current water clarity information and historical trends on all volunteer monitored lakes.

Online Lakes Database address:

http://dataservices.epa.illinois.gov/waBowSurfaceWater

Data Evaluation

This section explains how the data collected by volunteer lake monitors are used to determine the **trophic state indices (TSI^{SD}, TSI^{TP}, TSI^{CHL})** and to evaluate **aquatic life use (ALU)** and **aesthetic quality use (AQU)** evaluations of these uses are based on water-body specific monitoring data believed to accurately represent existing conditions. The confidence level of the data is dependent on how well the monitors adhere to the VLMP training manual which is the **Quality Assurance Project Plan (QAPP)** for this program. Tier III equivalent monitors were audited by the coordinators in August or October to further raise the confidence level of their data. Monitoring data are used to assign an evaluation to the entire lake acreage as a single unit. Any identified use impairment leads to evaluating identifying potential causes of impairment and their sources. Finally, some data which may not directly relate to TSI or use assessment are evaluated. Methodology for the evaluation of these components is explained below.

Tier II monitoring data is focused on the representative site for a lake which stands as a surrogate for the entire lake. The vast majority of this level of monitoring has all of the basic elements contained in Tier III, but those elements are focused primarily on one location upon the lake. Finally, Tier I data is evaluated using a smaller set of elements and providing a greater margin of error. Tier I data can be used to make a less defined range of assessment for a particular body of water. Within this report, Tier I and II assessments can be used to draw parallels with the more defined lakes of the Tier III group.

With a few exceptions, the data evaluation mimics the processes used in the Illinois Integrated Water Quality Report and Section 303(d) List. The Integrated Report format is based on federal guidance for meeting the requirements of Sections 305(b), 303(d) and 314 of the Clean Water Act. The basic purpose of the report is to provide information to the federal government and the citizens of Illinois on the condition of surface water in the state. Freshwater lake acres are assessed for at least one designated use. Designated uses include Aesthetic Quality, Aquatic Life, Fish Consumption, Indigenous Aquatic Life, Primary Contact, Public and Food Processing Water Supply, and Secondary Contact. Each lake is assessed as Fully Supporting (good), Not Supporting (fair), or Not Supporting (poor), for each applicable designated use.

In the 2014 report, 47 percent of total lake and pond acreage (318,477) in the state was assessed for at least one designated use. The major potential causes of impairment based on number of lake acres affected in the 2014 report are total suspended solids, phosphorus (total) and aquatic algae, impairing aquatic life and aesthetic quality uses; atrazine, manganese and simazine, impairing public and food processing water supply use; and, mercury and polychlorinated biphenyls (PCBs) in fish tissue impairing fish consumption use. At the same time, the major potential sources of impairment are crop production (crop land or dry land), littoral/shore area modifications (non-riverine), other recreational pollution sources, atmospheric deposition of toxics, runoff from forest/grassland/parkland, urban runoff/storm sewers, municipal point source discharges, animal feeding operations, contaminated sediments, and on-site treatment systems (septic systems and similar decentralized systems).

> The Illinois EPA determines the resource quality of each assessment unit by determining the level of support of each applicable designated use. For each lake and for each designated use applicable to that lake, an Illinois EPA assessment concludes one of two possible use-support levels: —Fully Supporting or —Not Supporting. Fully Supporting means that the designated use is attained; Not Supporting means the use is not attained. To facilitate communicating these results, Illinois EPA also refers to Fully Supporting status (for a use) as Good resource quality; Not Supporting status is called Fair or Poor resource quality, depending on the degree to which the use is not attained. Uses determined to be Not Supporting are called —impaired, and waters that have at least one use assessed as Not Supporting are also called impaired. For each impaired use in each assessment unit, Illinois EPA attempts to identify potential causes and sources of the impairment.
>
> -Illinois Integrated Water Quality Report and Section 303(d) List, 2014

This report determines a level of support of aquatic life and aesthetic quality for each lake which concludes one of three possible outcomes as mentioned above: Fully Supporting (good), Not Supporting (fair), or Not Supporting (poor). These outcomes are not pass-fail, but a mechanism for lake managers to focus potential resources towards balancing current and future activities towards attaining and setting goals. For Not Supporting (fair) and Not Supporting (poor) outcomes, examples of potential causes and sources for these lower classifications are given.

In general, evaluations that are based on data meeting IEPA's QA/QC requirements are considered having "Good" evaluation confidence and may be used by the Agency in the Integrated Report for lake assessments. The QA/QC difference between Tier II and Tier III is an audit conducted in August or October to ensure that field sampling is consistent with the field manual (VLMP Training Manual) and the collection of an equipment blank (if a beta bottle is used) and field blank.

	Evaluation Use	Evaluation Type	Evaluation Confidence
Tier I	Trend Analysis	Physical	Fair
Tier II	Aquatic Life & Aesthetic Quality	Physical & Chemical	Fair
Tier III	Aquatic Life & Aesthetic Quality	Physical & Chemical	Good

Trophic State Determination

As mentioned in the background section above, a lake's ability to support plant and animal life defines its level of productivity, or trophic state. The large amount of water quality data collected by the VLMP can be complicated to evaluate. In order to analyze all of the data, it is helpful to use a trophic state index. A TSI condenses large amounts of water quality data into a single, numerical index. Different values of the index are assigned to different concentrations or values of water quality parameters. The TSIs generated are used to determine a lake's trophic state and use assessments for aquatic life and aesthetic quality.

A TSI based on median Secchi transparency, TSI^{SD}, for each lake is calculated to classify lakes according to their degree of eutrophication as evidenced by their ability to support plant growth. All three tiers collect Secchi depth information at all of their active stations. Thus, TSIs from Secchi data assesses the condition of the lake as a whole. Tier III collects total phosphorus and chlorophyll-a data from all of its active sites, so TSI assessments for total phosphorus (TSI^{TP}) and chlorophyll (TSI^{CHL}) are also whole lake assessments. Finally, Tier II collects total phosphorus and chlorophyll-a data at site 1 only and stands as a surrogate for the whole lake assessment.

TSI Equations	Where,
$TSI^{SD} = 60 - (14.4)(LN(SD))$	SD = Secchi depth transparency (m)
$TSI^{TP} = 4.15 + (14.42)(LN(TP))$	TP = total phosphorus concentration (mg/L)
$TSI^{CHL} = 30.6 + (9.81)(LN(CHL))$	CHL = chlorophyll-a concentration (ug/L)
$TSI^{TN} = 54.45 + (14.43)(LN(TN))$	TN = total nitrogen concentration (mg/L)

Trophic State	TSI	Secchi Depth (in)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Chlorophyll-*a* (mg/L)
Oligotrophic	Less than 40	Greater than 145	Less than 0.367	Less than 0.012	Less than 2.5
Mesotrophic	40 to 50	79 to 145	0.367 to 0.735	0.012 to 0.025	2.5 to 7.5
Eutrophic	50 to 70	18 to 79	0.735 to 2.938	0.025 to 0.100	7.5 to 55
Hypereutrophic	Greater than 70	Less than 18	Greater than 2.938	Greater than 0.100	Greater than 55

The tiered approach of the volunteer program presents a situation where the accuracy of the data to make use assessment throughout the lake increases as the volunteer advances though the tiers. To help volunteers in Tier I and II make comparisons to Tier III, the data assessments for transparency, total phosphorus and chlorophyll-a are presented as whole-lake (WL) and representative site only (S1). The primary reason is based on Tier II collection of water quality samples for laboratory analysis at the representative site only. Most often, the representative site is located at site 1 of a particular lake. To further help the Tier I and II volunteer choose the best Tier III lakes for comparison, the lake statistics will also be provided within the evaluation. Useful lake statistics in order of importance are lake type (morphology), acreage & depth, and geographical location.

Aquatic Life Use

ALU is the tool used for evaluating aquatic life conditions in lakes using:

- The TSI for Secchi depth (TSI^{SD}), Total Phosphorus (TSI^{TP}), or *Chlorophyll-a* (TSI^{CHL}),
- The average recorded percent macrophyte coverage of the lake bottom during the peak growing season of June, July and August, and
- The median concentration of nonvolatile suspended solids (NVSS); calculated by the subtraction of VSS values from the TSS values.

These three components are used to calculate ALU scores for each TSI. Higher ALU scores indicate potential increases in unfavorable conditions as they relate to Aquatic Life use.

Evaluations of ALU are based on physical and chemical water quality data collected from the current year only. The physical and chemical data used include:

- Secchi disk transparency (meters),
- Total Phosphorus (ug/L) (epilimnetic samples only),
- *Chlorophyll-a* (ug/L),
- NVSS (mg/L) (epilimnetic samples only), and
- Percent surface area of macrophyte coverage.

Chemical data are collected four times, May, June, July, and August, at site 1 for Tier II monitors. Tier III monitors also collect samples in October and monitor more than one site during the sampling season. Tier III monitors may also collect a bottom sample for analysis (two feet off of the bottom) at one or more site locations. Secchi monitoring data are collected 12 times, twice a month from May through October.

Data goals for evaluations are:

- The three water collection events from June, July, and August (NVSS and TP data from May and October), and
- The six Tier I equivalent monitoring events from June, July and August (Secchi readings and percent macrophyte coverage of lake bottom).

TSI values are calculated for:

- Median Secchi disk transparency (SD) values using "=60-LN(meters SD)*14.4",
- Median TP values (epilemnetic sample only) using "=LN(ug/L TP)*14.4+4.15", and
- Median *chlorophyll-a* values using "=LN(ug/L *CHL-a*)*9.81+30.6"

Note: LN is the natural logarithm.

A minimum of two parameter-specific TSI values are needed for comparison to effectively evaluate ALU. Only Tier II and Tier III equivalent lakes collect chemical data making a complete evaluation possible. However, Tier I lakes can still compare their physical TSI^{SD} and percent macrophyte coverage to similar lakes to help develop potential goals. It should be noted that Secchi readings shortened due to being hidden by aquatic plant growth or by resting on the bottom of the lake are not used in calculating TSI^{SD} values, as they have not reached their normal vanishing point distance.

Evaluation Factor	Weighting Criteria for ALU	Points
Trophic State Index	Less than 60	40
	60 to (but not equal to) 85	50
	85 to (but not equal to) 90	60
	90 or greater	70
Macrophyte Coverage	Less than 5	15
	5% to 25%	0
	26% to 50%	5
	51% to 70%	10
	Greater than 70%	15
NVSS Concentration	Less than 12	0
	12 to (but not equal to) 15	5
	15 to (but not equal to) 20	10
	20 or greater	15

Aquatic Life Use	Guidelines
Fully Supporting Good	Total ALU points are less than 75
Not Supporting Fair	Total ALU points are greater than or equal to 75, but less than 95
Not Supporting Poor	Total ALU points are equal to 95 or greater

Identifying Potential Causes of ALU Impairment

When an ALU is found to be less than "Good" in a particular lake, potential causes should be identified.

Potential Causes for Impaired Aquatic Life Conditions
Chemical
Chloride: Acute - 500 mg/L
Ammonia
Phosphorus (Total): Acute - 0.05 mg/L in lakes with 20 acres or greater
Oxygen, dissolved
pH: Acute - Less than 6.5 or greater than 9.0
Non-Chemical Causes
Alteration in stream-side or littoral vegetative covers
Alteration in wetland habitats
Fish kills
Non-native aquatic plants
Non-native fish, shellfish, or zooplankton
NOTE: If other data is available on a lake collected by IEPA or otherwise submitted to IEPA for assessments, other general use standards may apply.

Identifying Potential Sources for ALU Impairment

Identifying potential sources related to the reduction in aquatic life conditions and aesthetic quality is essential in setting effective goals for lake managers. Information used to identify potential sources include Facility-Related Stream Survey data, ambient monitoring data, effluent monitoring data, facility discharge monitoring reports, review of National Pollutant Discharge Elimination System permits and compliance records, land use data, personal observations, and documented site-specific knowledge. The last two are what lake managers primarily rely. See Table 14 for a list of potential sources.

Aesthetic Quality Use

AQU is the tool used for evaluating aquatic life conditions in lakes using:

- The TSI for Secchi depth (TSI^{SD}), Total Phosphorus (TSI^{TP}), or *Chlorophyll-a* (TSI^{CHL}),
- The average recorded percent macrophyte coverage of the lake bottom during the peak growing season of June, July and August, and
- The median concentration of nonvolatile suspended solids (NVSS); calculated by the subtraction of VSS values from the TSS values.

These three components are used to calculate AQU scores for each TSI. Higher AQU scores indicate potential increases in unfavorable conditions as they relate to Aesthetic Quality use.

Evaluations of AQU are based on physical and chemical water quality data collected from the current year only. The physical and chemical data used include:

- Secchi disk transparency (meters),
- Total Phosphorus (ug/L) (epilimnetic samples only),
- *Chlorophyll-a* (ug/L),
- NVSS (mg/L) (epilimnetic samples only), and
- Percent surface area of macrophyte coverage.

Chemical data are collected four times, May, June, July, and August, at site 1 for Tier II monitors. Tier III monitors also collect samples in October and monitor more than one site during the sampling season. Tier III monitors may also collect a bottom sample for analysis (two feet off of the bottom) at one or more site locations. Secchi monitoring data are collected 12 times, twice a month from May through October.

Data goals for evaluations are:

- The three water collection events from June, July, and August (NVSS and TP data from May and October), and
- The six Tier I equivalent monitoring events from June, July and August (Secchi readings and percent macrophyte coverage of lake bottom).

Whole-lake TSI values are calculated for:

- Median Secchi disk transparency (SD) values using “=60-LN(meters SD)*14.4”,
- Median TP values (epilemnetic sample only) using “=LN(ug/L TP)*14.4+4.15”, and
- Median *chlorophyll-a* values using “=LN(ug/L *CHL-a*)*9.81+30.6”

Note: LN is the natural logarithm.

A minimum of two parameter-specific TSI values are needed for comparison to effectively evaluate AQU. Only Tier II and Tier III equivalent lakes collect chemical data making a complete evaluation possible. However, Tier I lakes can still compare their physical TSI^{SD} and percent macrophyte coverage to similar lakes to help develop potential goals. It should be noted that Secchi readings shortened due to being hidden by aquatic plant growth or by resting on the bottom of the lake are not used in calculating TSI^{SD} values, as they have not reached their normal vanishing point distance.

Evaluation Factor	Weighting Criteria for AQU	Points
Trophic State Index	Actual TSI Value	Actual TSI Value
Macrophyte Coverage	Less than 5	0
	5% to 25%	7.5
	Greater than 25%	15
NVSS Concentration	Less than 3	0
	3 to (but not equal to) 7	5
	7 to (but not equal to) 15	10
	15 or greater	15

Aesthetic Quality Use	Guidelines
Fully Supporting Good	Total AQU points are less than 60
Not Supporting Fair	Total AQU points are greater than or equal to 60, but less than 90
Not Supporting Poor	Total AQU points are equal to 90 or greater

Identifying Potential Causes of AQU Impairment

When an AQU is found to be less than “Good” in a particular lake, potential causes should be identified.

Potential Causes for Impaired Aesthetic Quality Causes
Potential Cause
Sludge, Bottom Deposits, Floating Debris, Visible Oil, Odor,
Aquatic Algae, Aquatic Plants (Macrophytes), Color, Turbidity
Total Phosphorus: In lakes greater than 20 acres where macrophytes and algae growth are the cause, nutrients are considered a contributing cause.
Phosphorus (Total): Acute: 0.05 mg/L in lakes with 20 acres or greater

Identifying Potential Sources for ALU Impairment

Identifying potential sources related to the reduction in aquatic life conditions and aesthetic quality is essential in setting effective goals for lake managers. Information used to identify potential sources include Facility-Related Stream Survey data, ambient-monitoring data, effluent-monitoring data, facility discharge monitoring reports, review of National Pollutant Discharge Elimination System permits and compliance records, land use data, personal observations, and documented site-specific knowledge. The last two are what lake managers primarily rely. See Appendix A: Table 13 for a list of potential sources.

Other Data

Nitrogen

Nitrogen, like phosphorus, is an important nutrient for macrophyte and algae growth in lakes. The amount of nitrogen in lake water depends on the local land use and may enter a lake from surface runoff or groundwater sources. It should be noted that nitrogen compounds often exceed 0.5 mg/L in rainfall (Shaw, Mechenich & Klessig 2004).

Lake water nitrogen exists primarily in three categories analyzed through this program; nitrate (NO_3^-) plus nitrite (NO_2^-), ammonium (NH_4^+ and NH_3), and Kjeldahl nitrogen (TKN). Total nitrogen (TN) is calculated by adding nitrate and nitrite to TKN. Organic nitrogen can be back calculated by subtracting ammonium from TKN.

In the absence or low levels of inorganic forms of nitrogen, nuisance blue-green algae blooms can occur. The blue-green algae can use the atmospheric nitrogen gas (N_2). While useful to aquatic plants, higher levels of inorganic nitrogen are harmful to many aquatic animals.

Unlike total phosphorus, there is no Illinois Water Quality Standard for total nitrogen; however, there is several benchmark values considered to be useful for evaluating water for the protection of various aquatic species.

Total Nitrogen and Inorganic Nitrogen benchmarks recommended
for protection of sensitive aquatic animals.

Nitrogen	Short Term Exposure (Acute)	Long Term Exposure (Chronic)
TN (TKN+NO_2+NO_3)	10.00 mg/L	1.00 mg/L
Nitrite (NO_2)	0.35 mg/L	
Nitrate (NO_3)	10.00 mg/L	2.90 mg/L
Ammonia (NH_3)	0.35 mg/L	0.02 mg/L

(US EPA, 1986, 1999; Environment Canada, 2001; Constable et al., 2003; Alonso, 2005)

Ranges and Descriptions for Nitrogen to Phosphorus Ratios Based on Algal Growth Limiting Nutrient.

Nitrogen : Phosphorus (N:P) Ratio	Algae Growth Limiting Factor	Descriptions
Less than 14:1	Nitrogen limited	Nitrogen limits most algae growth; blue-green algae more likely present
14:1 to 30:1	Transitional	A variety of situations may arise depending on actual N and P concentrations. Other factors may be predominant in limiting algae growth; such as available sunlight.
Greater than 30:1	Phosphorus limited	Phosphorus limits algae growth

Chlorides

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution. Sources of chloride include septic systems, animal waste, potash fertilizer (potassium chloride), and drainage from road-salting chemicals. Since lakes vary in their natural chloride content, it is important to have background data or a long term database to document changes. The water quality standard for chloride is 500 mg/L.

Alkalinity

Alkalinity is used to determine how resistant a lake is to any change in pH. For example, making the lake less sensitive to acid rain, as the bicarbonate$^-$ and carbonate$^=$ ions neutralize the acid's hydronium$^+$ ions. This buffering capacity is described by Taylor 1984 using four categories of sensitivity (See Table). The Agency reports Alkalinity values in mg/L.

Sensitivity to Acid Rain	Alkalinity Value (mg/L $CaCO_3$)
High	0-2.0
Moderate	2-10
Low	10-25
Non-sensitive (well buffered)	Greater than 25

Aquatic Invasive Species

Throughout the sampling season, volunteers mark the presence of aquatic invasive species. This data is added to historical information and used to prepare special maps to follow the spread of these AIS. The data is then collated and provided to the regional field biologists or other experts for potential validation, if applicable. Currently, a ***Hydrilla Hunt!*** is being heavily pressed. The current watch lists include the following.

Eurasian Watermilfoil	Brazilian Elodea	Quagga Mussel	Ruffe
Curly Leaf Pondweed	Water Chestnut	Common Carp	Spiny Waterflea
Hydrilla	Water Lettuce	Grass Carp	Fishhook Waterflea
Water Hyacinth	Purple Loosestrife	Asian Carp	Rusty Crayfish
European Frogbit	Zebra Mussel	Round Goby	New Zealand Mudsnail

Results and Discussion

Basic Monitoring Program

Lakes

One-hundred twenty-eight (128) lakes were monitored at least once in 2014. These lakes are distributed across the state with clusters occurring in several areas (Figures 1 and 1-1). The type of lakes in the program include glacial, impoundments (dammed, dug), old quarries (coal, sand, gravel, burrow) and ponds. The size of the lakes in the program varied greatly, from the 4,200 acre impoundment reservoir, Springfield Lake of Sangamon County, to the one acre impoundment lake, Stephen Lake of Will County. Volunteers covered 37,536 acres of lake surface water (Appendix A: Table 3). The public's access to these lakes turned out to be 56 percent (Figure 3). The private access ranged from single owner to multiple homeowner housing developments, even forest preserve lakes with limited access (Figure 4 & Appendix A: Table 3). The maximum depth of these lakes ranged from three and a half feet at Potomac of Lake County to 100 feet at Devil's Kitchen in Williamson County. The VLMP had lakes in 23 of the 33 major watersheds in the state. The three watersheds with the highest density of VLMP lakes were the Upper Fox with 39 lakes, Des Plaines with 27 lakes, and Big Muddy with 12 (Appendix A: Table 3). Figure 2 shows the distribution of the 33 major watersheds in Illinois.

Figure 3. Lake Access

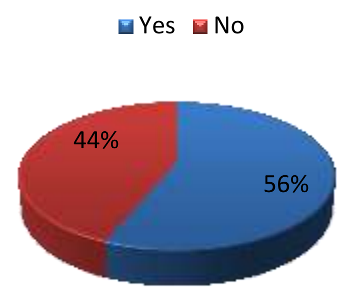
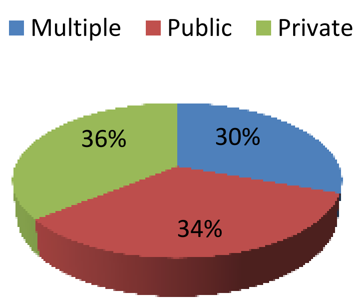


Figure 4. Lake Ownership

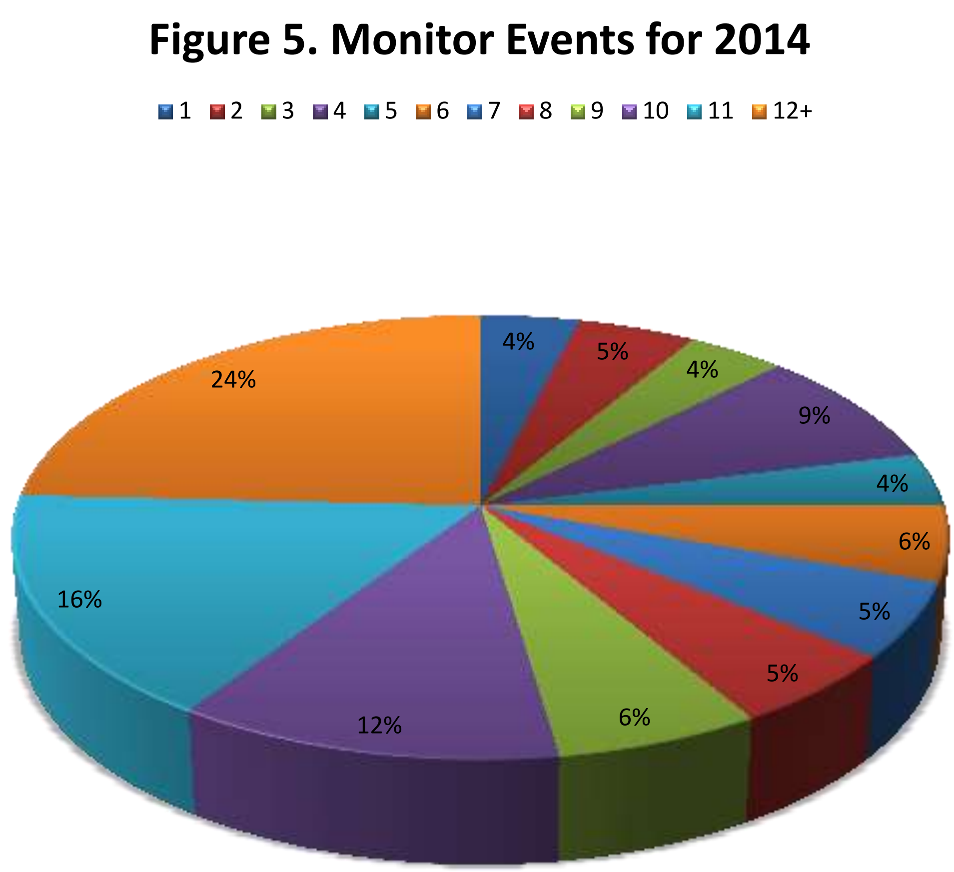


Volunteers

Two-hundred thirty-four (234) volunteers participated in the monitoring during 2014. These monitors donated over 3,042 volunteer-hours of their time for 1,083 monitoring events. Volunteers are primarily lakeshore residents, lake owner/managers, sportspersons, environmental group members, public water supply personnel, and interested citizens (Appendix A: Table 1 & Page 3: Acknowledgements).

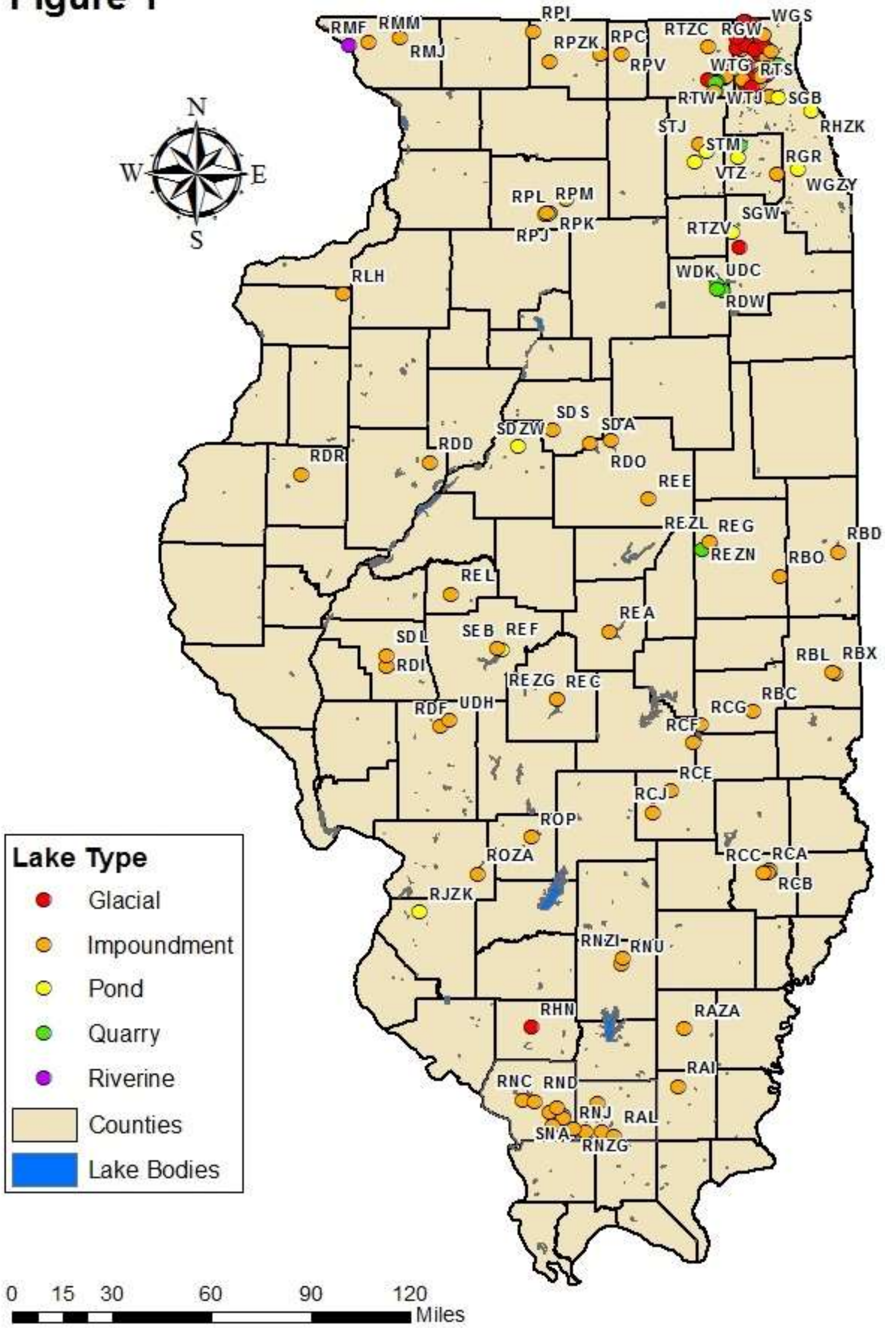
Data Returns

Thirty-one (31) lakes had a 100 percent data return (sampled during all 12 monitoring periods). Forty-four (44) lakes had nine to 11 data returns, 21 had six to eight data returns, 21 had three to five data returns, and 11 had less than three data returns (Appendix A: Table 1 and Figure 5).



2014 VLMP Lakes

Figure 1



2014 VLMP Lakes, Lake County

Figure 1-1

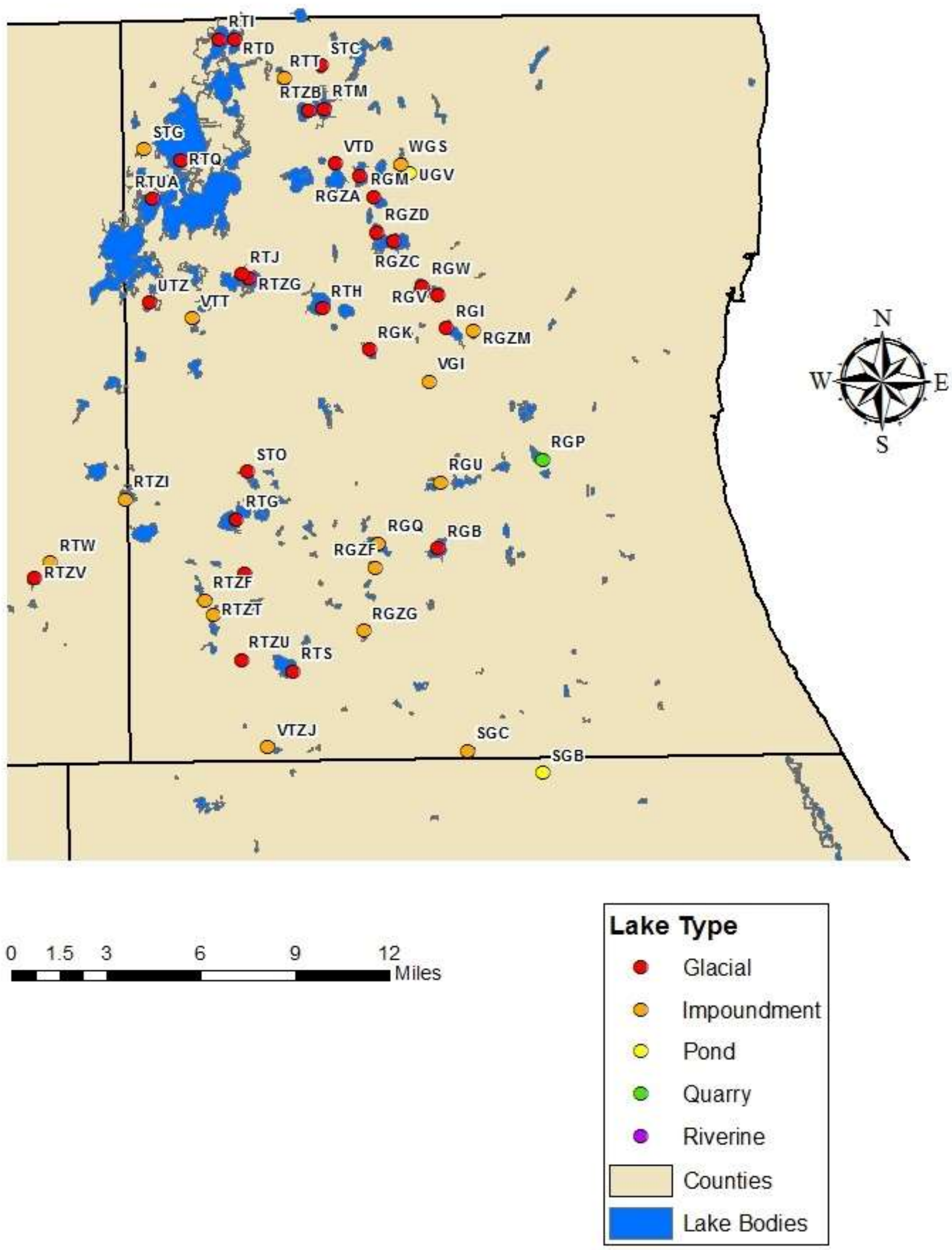
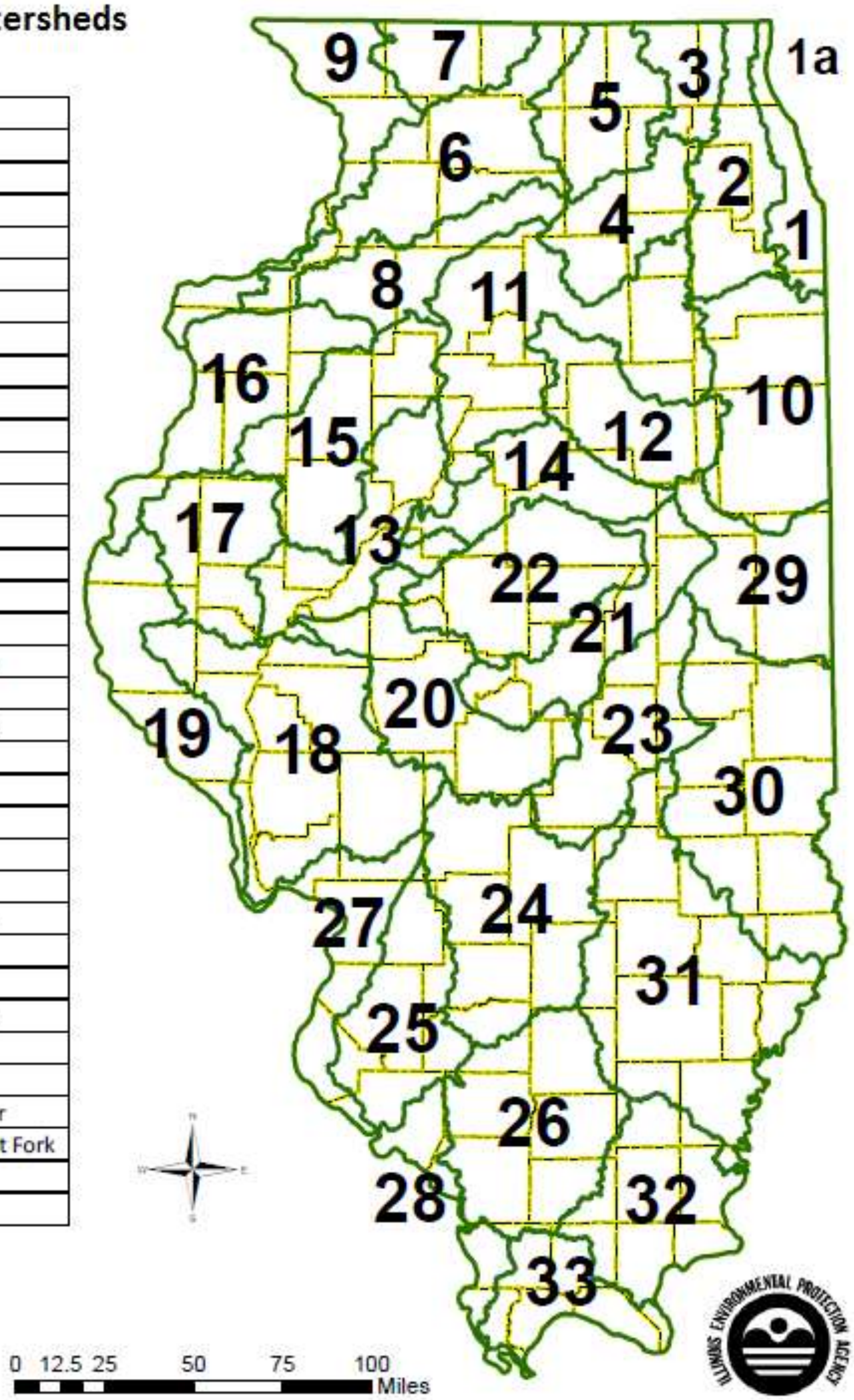


Figure 2 Major Watersheds

No.	Watershed Name
1	Great Lakes/Calumet River
1a	Lake Michigan Beaches
2	Des Plaines River
3	Upper Fox River
4	Lower Fox River
5	Kishwaukee River
6	Rock River
7	Pecatonica River
8	Green River
9	Mississippi North River
10	Kankakee/Iroquois River
11	Upper Illinois/Mazon River
12	Vermilion (Illinois) River
13	Middle Illinois River
14	Mackinaw River
15	Spoon River
16	Mississippi North Central River
17	La Moine River
18	Lower Illinois/Macoupin Creek
19	Mississippi Central River
20	Lower Sangamon River
21	Upper Sangamon River
22	Salt Creek of Sangamon River
23	Upper Kaskaskia River
24	Middle Kaskaskia/Shoal Creek
25	Lower Kaskaskia River
26	Big Muddy River
27	Mississippi South Central River
28	Mississippi South River
29	Vermilion (Wabash) River
30	Embarras/Middle Wabash River
31	Little and Lower Wabash/Skillet Fork
32	Saline River/Bay Creek
33	Cache River



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The following 31 lakes were sampled all 12 periods:

Lake Name/County Name	Lake Name/County Name	Lake Name/County Name
Altamont New/Effingham	Lake of Egypt/Williamson	Spring/McDonough
Barrington/Lake	Lake of the Hollows/Lake	Sunset/Lee
Bass/Lee	Leopold/Lake (13)*	Swan/Cook (14)*
Black Oak/Lee	Little Silver/Lake	Third/Lake
Buffalo Creek/Lake	Miller/Jefferson	Tower/Lake
Charles/DuPage	Pine/Lee	Valley/Lake
Deep/Lake	Richardson Wildlife/Lee	Virginia/Cook
Diamond/Lake	Sara/Effingham	Waterford/Lake (17)*
Fourth/Lake	Silver/McHenry	Woodhaven/Lee (13)*
Galena/Jo Daviess	Spring Arbor/Jackson	Zurich/Lake (13)*
La Fox Pond/Kane		

- The number in parenthesis denotes actual number of events monitored when more than twelve.

Transparency Ranking

One-hundred twenty-eight median summer Secchi depths (in inches) are ranked highest to lowest and summarized in the lists below. The list is divided into the four trophic classes. Appendix A: Table 2 lists the ranking from the highest median transparency to the lowest.

Oligotrophic

Rank	Lake/County/Code	SD	Rank	Lake/County/Code	SD
1	Civic/Grundy/WDK	436.5	4	Three Oaks South/McHenry/WTG	239.0
2	Virginia/Cook/SGB	270.0	5	Three Oaks North/McHenry/WTJ	229.0
3	Deep/Lake/VTD	239.0			

Mesotrophic

Rank	Lake/County/Code	SD	Rank	Lake/County/Code	SD
6	West Loon/Lake/RTZB	154.5	15	Beaver/Grundy/RDW	101.0
7	Goose/Grundy/SDZB		16	Minear/Lake/RGP	99.0
8	McCamey/Fulton/VDB		17	Charlotte/Kane/VTZ	96.0
9	Diamond/Lake/RGB	114.0	18	Leopold/Lake/VGI	96.0
10	Druce/Lake/RGV	108.0	19	Cross/Lake/UTV	90.0
11	Zurich/Lake/RTS	108.0	20	Spring Arbor/Jackson/RNZG	87.0
12	Little Silver/Lake/STC	105.0	21	Sunset/Champaign/REZN	85.0
13	Killarney/McHenry/RTZV		22	Gages/Lake/RGI	
14	Bangs/Lake/RTG		23	Highland/Lake/RTZP	

Eutrophic

Rank	Lake/County/Code	SD	Rank	Lake/County/Code	SD
24	Petersburg/Menard/REL	78.5	66	Charles/DuPage/RGR	38.0
25	Gamlin/St. Clair/RJZK	74.0	67	Woods Creek/McHenry/RTZZ	38.0
26	Candlewick/Boone/RPV	72.0	68	Chicago Botanic Gardens/Cook/RHJA	37.0
27	Miltmore/Lake/RGZD	72.0	69	Longmeadow/Cook/RHZK	37.0
28	Kincaid/Jackson/RNC	69.0	70	Bluff/Lake/VTJ	37.0
29	Silver/McHenry/RTW	66.0	71	Potomac/Lake/RGZK	36.5
30	Spring Ledge/Lake/UGV	64.0	72	Sara/Effingham/RCE	36.0
31	Third/Lake/RGW	64.0	73	Fourth/Lake/RGZC	36.0
32	Fyre/Mercer/RLH	62.0	74	Stephen/Will/SGW	36.0
33	East Loon/Lake/RTM	61.0	75	Bird's Pond/Sangamon/SEB	35.0
34	New Thompson/Jackson/RNZO	60.0	76	Olney East Fork/Richland/RCC	34.0
35	Lake of the Hollow/Lake/UTZ	60.0	77	Galena/Jo Daviess/RMM	33.0
36	Highwood/McHenry/STB	60.0	78	Bloomington/McLean/RDO	33.0
37	Devils Kitchen/Williamson/RNJ	60.0	79	Borah/Richland/RCB	33.0
38	Apple Canyon/Jo Daviess/RMJ	58.0	80	Ossami/Tazewell/SDZW	33.0
39	Waterford/Lake/WGS	58.0	81	Tower/Lake/RTZF	32.0
40	Pine/Lee/RPZB	56.5	82	Bass/Lee/RPJ	31.0
41	Butler/Lake/RGJ	56.0	83	Sunset/Macoupin/UDH	31.0
42	Linden/Lake/RGC	56.0	84	Lake of the Woods/Champaign/REG	30.0
43	Lake of Egypt/Williamson/RAL	56.0	85	Murphysboro/Jackson/RND	30.0
44	Lambert/DuPage/SGG	54.0	86	Catherine/Lake/RTD	30.0
45	Cedar/Jackson/RNE	52.0	87	Marie/Lake/RTR	30.0
46	Valley/Lake/RGZM	51.0	88	Evergreen/McLean/SDA	30.0
47	La Fox Pond/Kane/STM	49.0	89	Jacksonville/Morgan/RDI	30.0
48	Jaycee/Jefferson/RNU	48.0	90	Petite/Lake/VTW	28.0
49	Honey/Lake/RTZU	48.0	91	Channel/Lake/RTI	27.0
50	Joliet Jr College/Will/WGZ	48.0	92	Miller/Jefferson/RNZI	26.0
51	Summerset/Winnebago/RPI	47.5	93	Otter/Macoupin/RDF	26.0
52	Long/Lake/RTJ	46.0	94	Homer/Champaign/RBO	24.0
53	Vernor/Richland/RCA	45.0	95	Briarwood/Cook/SGI	24.0
54	Sand/Lake/RGM	44.5	96	Barrington/Lake/RTZT	24.0
55	Swan/Cook/WGZY	44.0	97	Loch Lomond/Lake/RGU	24.0
56	Altamont New/Effingham/RCJ	42.0	98	Spring/Lake/RGZT	24.0
57	Antioch/Lake/RTT	42.0	99	Black Oak/Lee/RPK	24.0
58	Sunset/Lee/RPL	42.0	100	Dawson/McLean/REE	24.0
59	Richardson Wildlife/Lee/RPZI	41.5	101	Redhead/Lake/RTV	23.0
60	Countryside/Lake/RGQ	41.0	102	Waverly/Morgan/SDC	22.0
61	Herrin Old/Williamson/RNZD	41.0	103	Chautauqua/Jackson/SNA	21.0
62	Weslake/St. Clair/RJJ	40.5	104	Vermilion/Vermilion/RBD	21.0
63	Goose/McHenry/RTZS	40.0	105	Spring/McDonough/RDR	20.5
64	Westlake/Winnebago/RPZK	39.0	106	Buffalo Creek/Lake/SGC	20.0
65	Woodhaven/Lee/RPM	38.5			

Hypereutrophic

Rank	Lake/County/Code	SD	Rank	Lake/County/Code	SD
107	Pistakee/Lake/RTU	19.0	118	Forest/Lake/RGZG	14.0
108	Wonder/McHenry/RTZC	19.0	119	Springfield/Sangamon/REF	14.0
109	Paris Twin East/Edgar/RBL	18.0	120	Dunns/Lake/VTH	13.5
110	Pierce/Winnebago/RPC	18.0	121	Grass/Lake/RTQ	13.0
111	Twin Oaks/Champaign/REZL	17.5	122	Nippersink/Lake/RTUA	13.0
112	Paris Twin West/Edgar/RBX	17.0	123	Mattoon/Shelby/RCF	13.0
113	Benton/Franklin/RNO	17.0	124	Highland Silver/Madison/ROZA	13.0
114	Matthews/Lake/UTA	16.5	125	Paradise/Coles/RCG	9.0
115	Taylorville/Christian/REC	15.0	126	Napa Suwe/Lake/STO	9.0
116	Beaver Pond/DuPage/WTK	15.0	127	Carbondale/Jackson/RNI	7.5
117	Fox/Lake/RTF	15.0	128	Forest/Lake/WHC	6.0

Ranking in this report provides a means for participants to find and consider lakes undergoing similar processes. To help this comparison, Figures 6a through 6d rank the lakes within four of the five specific lake types categorized and studied within this report; Glacial, Impoundment, Quarry, and Pond. Riverine/Backwater is the fifth lake type, but had no representative this year.

Civic Lake in Grundy County had the greatest transparency with a median value of 436.5 inches (nearly spot on last year's value). Civic is a quarry lake, created from coal strip mining. Civic's primary water source is groundwater. The lowest median transparency goes to Forest (an impoundment) of Lake County. Civic Lake also had the highest single transparency reading of 567 inches.

The majority of these lakes follow a similar linear morphology where turbid water from a stream or river flows into a wider lake bed. The water slows, allowing particulates to drop out of the water to form lake sediments and reducing turbidity. Site 1 is typically the furthest site from the inlets, as well as the deepest part of the lake (especially for impoundment lakes). Best management practices (BMP) that target reducing turbidity in the lakes that show this shift are likely to benefit water clarity to a high degree. See Appendix A: Table 10 for a list of BMPs. Additionally, this change in transparency highlights the necessity to use other means to predict algal biomass and trophic state in waters that have high turbidity related to NVSS.

Figure 6a: Glacial Lake MedianTransparencies (Inches) (33 Lakes)

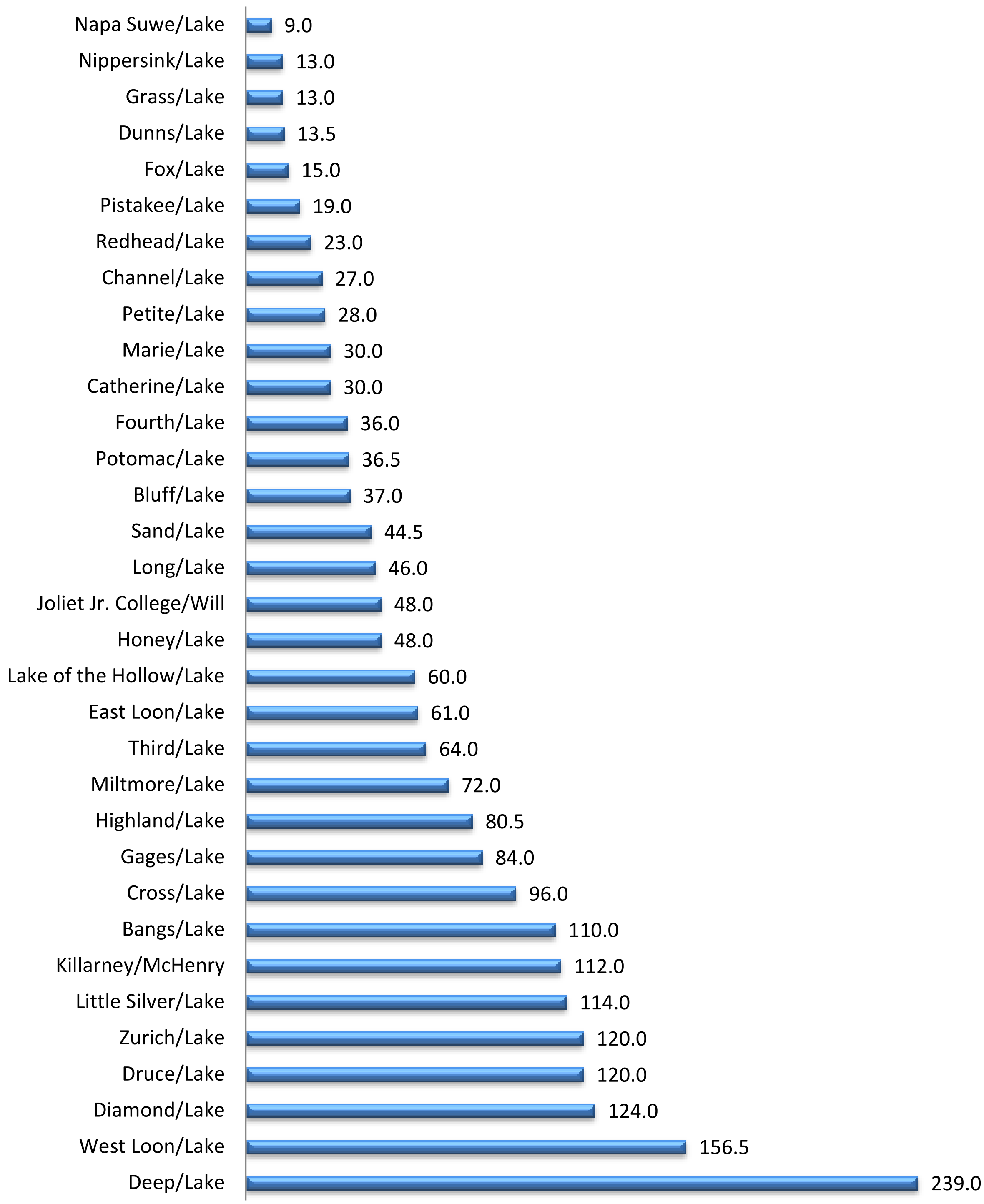


Figure 6b: Impoundment Lake Median Transparencies (Inches) (71 Lakes)

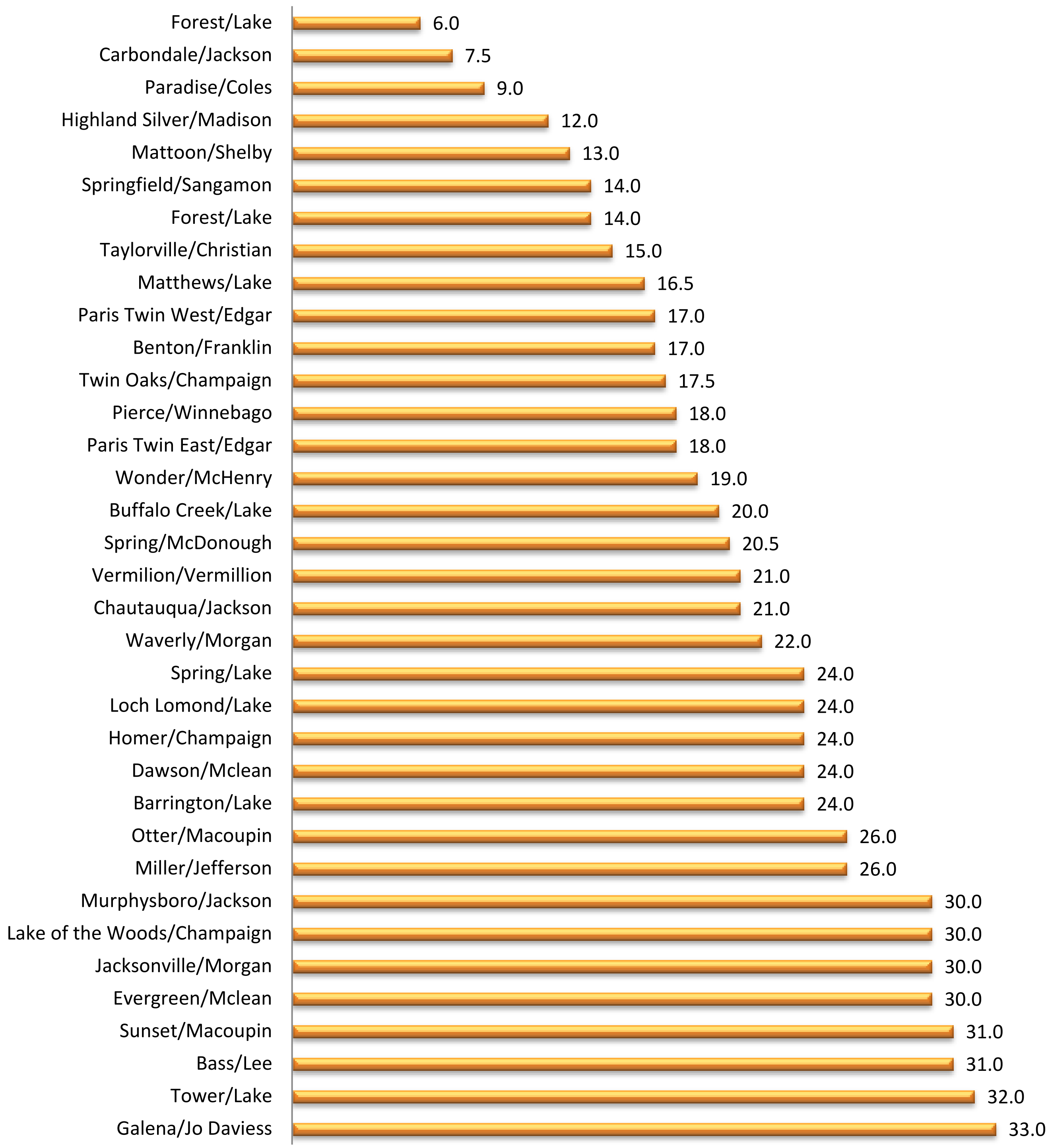


Figure 6b: Impoundment Lake Median Transparencies (Inches) (71 Lakes) 'Continued'

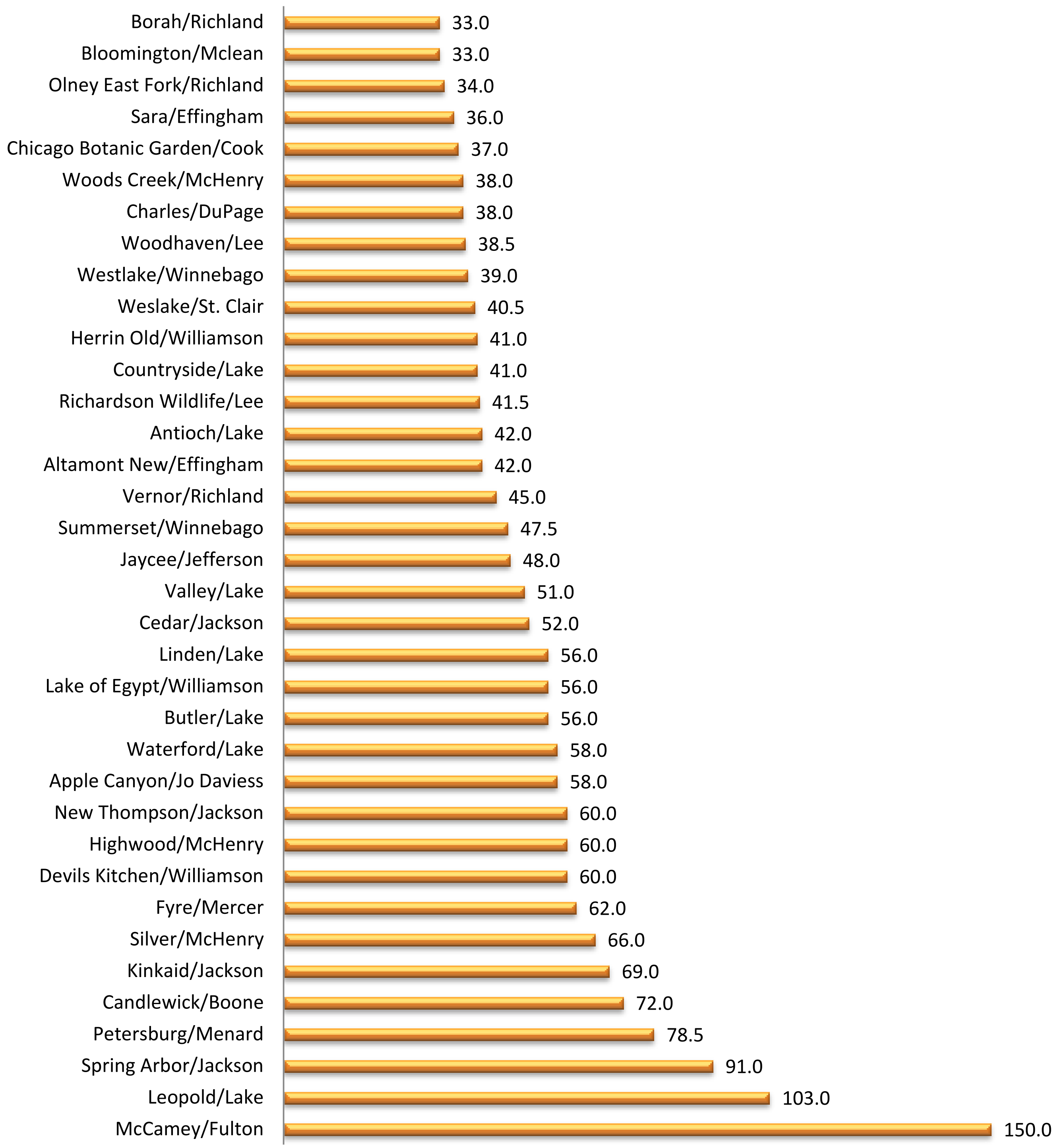


Figure 6c: Pond Median Tranparencies (Inches) (15 Ponds)

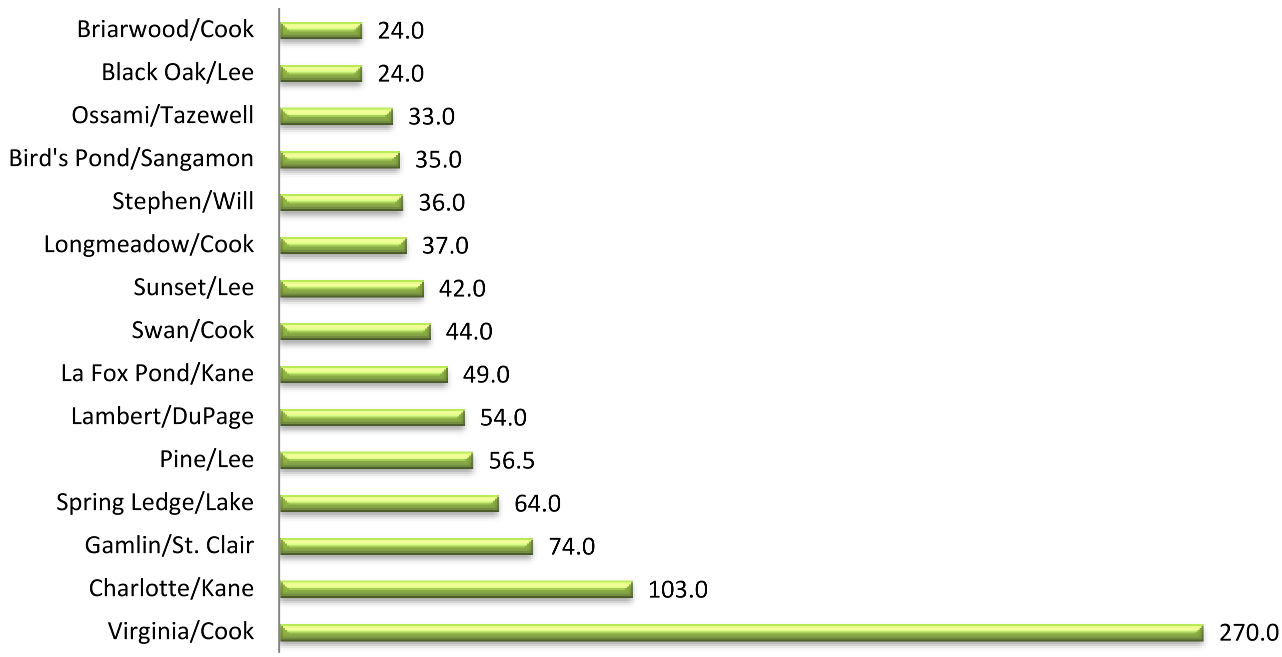
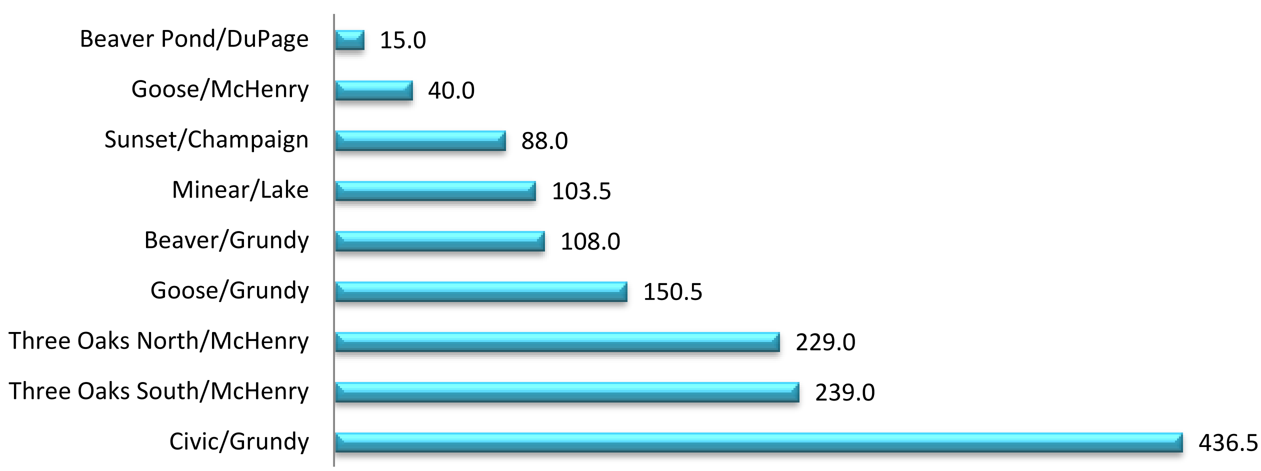


Figure 6d: Quarry Lake Median Transparencies (Inches) (9 Quarries)



Transparency Variability

Average transparency data for all the years a lake has been monitored is available online at http://dataservices.epa.illinois.gov/waBowSurfaceWater. The collection of annual average Secchi transparencies helps establish a “trend” for that lake. A trend is a way to describe the pattern of data over a certain time period. Increasing, decreasing and fluctuating are all terms used to describe the Secchi transparency trend for a particular lake.

Trends based on lake median should be interpreted with caution. A lake’s median transparency for a particular year can be affected by a number of factors, such as:

1. Variations in meteorological conditions and precipitation patterns,
2. Water depths,
3. Variations in the timing and frequency of monitoring,
4. Variations in monitoring techniques and perceptions by different volunteers,
5. Exact location of sampling sites,
6. Growth of aquatic plants that can inhibit the depth to which the Secchi disk can physically be lowered,
7. Variations in management of lake, like plant treatments, drawdowns etc., and
8. Spills, construction, or other temporary human impacts.

A technical analysis of lake trends should always consider these types of potential sampling errors and variability. Factors such as the minimum and maximum transparencies for each year, seasonal patterns in transparency, effects of a particular storm event or management practice on transparency, and many other factors also should be examined when interpreting Secchi transparency trends. Hence, it is apparent that the most reliable data means are those derived from consistent and frequent monitoring throughout the season and over a period of years.

Percent Macrophyte Coverage

Volunteers made an estimate of the percent coverage of macrophytes (aquatic plants) visible on the lake surface. On many of Illinois’ lakes, the turbidity of the water limits the estimates to emergent species. Each range was given a weighted point value in regards to whether that coverage range is good (0 points) to poor (15 points) for “Aquatic Life Uses” and “Aesthetic Quality Uses.” See Appendix A: Tables 7a through 8b, under the subheading of %Cover.

Expanded Monitoring Programs

Water Quality Monitoring

In 2014, volunteers at 66 lakes collected water samples from one foot below the lake water surface. Seventeen of these lakes collected water samples for analysis at multiple stations on the lake, while the 53 other lakes sampled at the representative site only. Appendix A: Table 5 provides the mean values for all of the analytes studied. All of the water quality data are provided in Appendix C. Not all samples were analyzed for all constituents. Chloride analysis was limited to the general Chicago metropolitan area of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will counties. One Tier II lake did not collect chlorophyll samples.

Total Phosphorus: The median values ranged from 0.003 mg/L to 0.862 mg/L. The single highest value overall was found at Swan Lake in Cook County, 0.891 mg/L. Thirty-seven (37) lakes had median values of TP over the 0.05 mg/L. It should be noted that nine of 29 lakes with median TP under 0.05 mg/L had one or more sampling events with levels over that benchmark. Lake TSI^{TP}'s were calculated and are summarized in Appendix A: Table 4. The 20 lakes with values **all** under the benchmark are:

Bangs/Lake	Butler/Lake	Candlewick/Boone	Cedar/Jackson
Charlotte/Kane	Civic/Grundy	Deep/Lake	Devils Kitchen/Williamson
Druce/Lake	Herrin Old/Williamson	Killarney/McHenry	Lake of Egypt/Williamson
Leopold/Lake	Miltmore/Lake	Silver/McHenry	Spring Arbor/Jackson
Sunset/Champaign	Three Oaks North/McHenry	Three Oaks South/McHenry	Virginia/Cook

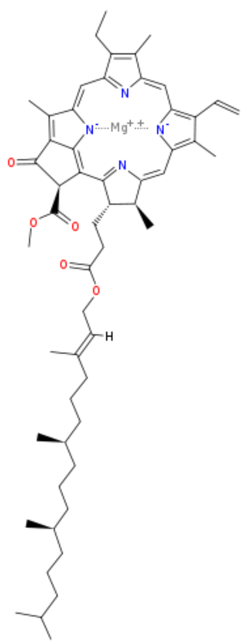
Nitrogen: Lakes were analyzed for three sources of nitrogen; ammonia, nitrites + nitrates, and Total Kjeldahl Nitrogen (TKN). Total Nitrogen to Total Phosphorus (TN:TP) ratios were calculated for the lakes (Appendix A: Table 6). These ratios indicate that 24 lakes are nitrogen limited, 28 are transitional, and16 are phosphorus limited. This spread of limiting nutrients highlights the need to consider both nutrients when creating a management plan.

Whether or not the nutrient identified as the limiting nutrient is truly the limiting factor for algal growth depends also on light availability. The amount of light available for algal growth varies depending on the amount of suspended solids in the water column, as well as the absorbency of the water's true color. Predation by zooplankton can also limit algal growth. It should be noted that some cyanobacteria have additional metabolic mechanisms to compensate for low phosphorus availability. Additionally, plotting the change of ratios over the course of the growing season for a particular lake may be useful for spotting seasonal trends, but is not within the scope of this report.

TN:TP ratios ranged from 2:1 at Swan Lake in Cook County to 275:1 at Three Oaks North in McHenry County. As mentioned earlier, when inorganic nitrogen (nitrate + nitrite + ammonia) is available over 0.3 mg/L in a lake, summer algae blooms should be expected. In lakes where inorganic nitrogen is low, but phosphorus is readily available, the lake's nutrient factors favor blue-green algae growth. Appendix A: Tables 6a and 6b summarize the median inorganic nitrogen, total nitrogen, total phosphorus, TN:TP ratios and are assigned a nutrient category; nitrogen limited (less than 15:1), phosphorus limited (greater than 30:1) or transitional (15:1 to 30:1).

Figure 8a is created from data collected at Tier II lakes and shows the distribution of the growth limiting nutrient categories. Remember, Tier II lakes collect water chemistry at site 1 only. Figure 8b is created from data collected at Tier 3 lakes and also shows the distribution of the growth limiting nutrient categories. These nutrient data were collected at multiple locations at the lake.

Chlorophyll-a: Lake TSI^{CHL} was calculated from chlorophyll data collected at 67 lakes. Data are summarized in Appendix A: Table 4. Median chlorophyll-a concentration values ranged from 0.53 *ug*/L at Three Oaks North in McHenry County to 135 *ug*/L at Westlake in Winnebago County. The median phosphorus levels for these two lakes were 0.003 mg/L and 0.132 mg/L, respectively. Additionally, Three Oaks North is phosphorus limited (N:P = 275:1), while Westlake is transitional (N:P = 22:1). Appendix A: Table 5 shows a direct correlation between increasing phosphorus levels and increased chlorophyll-a concentration.



Chlorophyll-a

Non-volatile Suspended Solids (NVSS): NVSS median values were calculated by subtracting the volatile suspended solids (VSS) from the total suspended solids (TSS). (TSS – VSS = NVSS). Appendix A: Table 6 summarizes these median values and Appendix A: Forty-seven of the 66 lakes showed no significant amounts of NVSS, less than 3 mg/L; while the rest were less than the 12 mg/L.

Chloride: None of the 32 lakes sampled for chloride had median values over the Agency’s water quality standard (WQS) for surface water of 500 mg/L. The median values ranged from 0 mg/L at Palmyra-Modesto in Macoupin

Figure 7: Limiting Nutrient (68 Lakes)

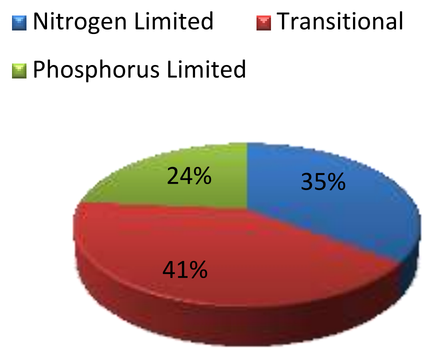


Figure 8a: Tier 2 Limiting Nutrient (56 Lakes)

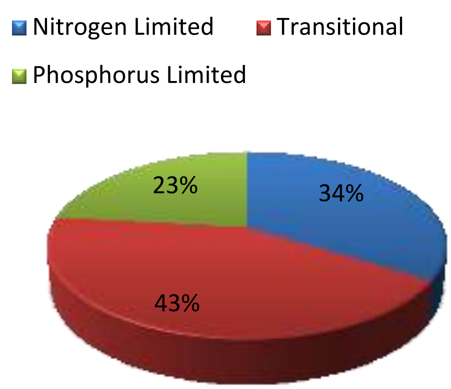
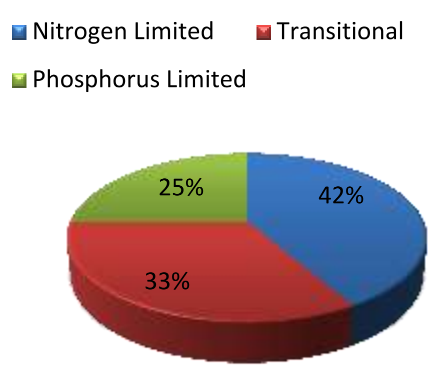


Figure 8b: Tier 3 Limiting Nutrient (12 Lakes)



County, to 377 mg/L at Potomoc in Lake County (Appendix A: Table 5). Chloride sampling was generally limited to the general Chicago metropolitan area of Cook, Kane, DuPage, McHenry, Lake, Will and Kendall counties. The WQS was not exceeded this year by any single sample for the lakes in this study. The highest single value returned was 499 mg/L at Loch Lomond in Lake County and the single lowest value returned was 2.83 mg/L at Virginia in Cook County.

Alkalinity: This year all but two lakes analyzed for alkalinity appear to be well buffered, with a range of 32 mg/L at Herrin Old in Williamson County to 262 mg/L at Longmeadow in Cook County (Appendix A: Table 5). Cedar in Jackson County and Devils Kitchen in Williamson County were both considered to be buffered to a low sensitivity range for acid rain. As mentioned previously, values greater than 25 mg/L are considered “well buffered,” while “low sensitivity” ranges between 10 and 25 mg/L. Using the USGS Hardness Scale; 17 were “Very Hard,” 31 were “Hard,” 13 were “Moderately Hard,” and six were “Soft.” Five of six with soft water were all found in Southern Illinois; Devils Kitchen and Herrin Old of Williamson County, Cedar of Jackson County, Miller of Jefferson County, and Lake of Egypt in Williamson County. Otter Lake of Macoupin County had a median alkalinity in the soft water range this year in the Central Illinois Region.

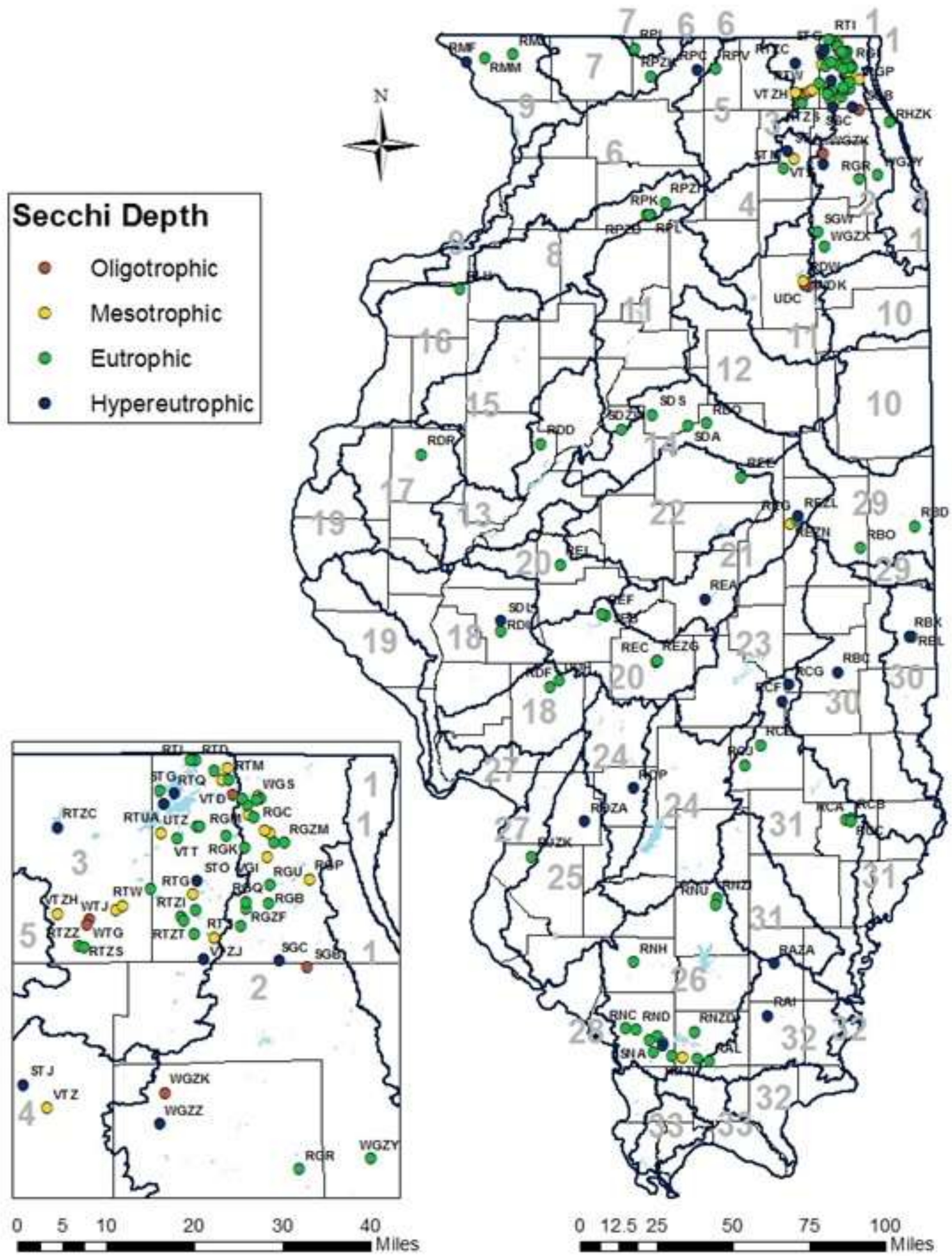
Trophic State Index

Trophic State Indexes were calculated for 128 lakes based on Secchi depth medians. A TSI^{TP} was also calculated for 68 of these lakes and a TSI^{CHL} was calculated for 67 of these lakes. (Appendix A: Table 4). Sixty lakes were Tier I and only had a single TSI to base the trophic state upon. Those lakes reflect some of the same data as found in the discussion of the Secchi depth transparency ranking section, above.

A watershed map (Figure 9) was created to show the distribution of the Secchi Depth trophic state across the state. The heaviest grouping of study lakes are found in the Upper Fox (#3), the Des Plaines (#2), and the Big Muddy (#26) watersheds, with 39, 27, and 12 VLMP lakes, respectively. The map presents the Upper Fox and Des Plaines watersheds in an expanded box in the lower left of the figure. Appendix A: Table 3 lists the major watershed for each volunteer lake with their corresponding basin number, as well as the national hydrologic unit code (HUC) system. A HUC is a sequence of numbers or letters that identify a hydrological feature like a river, river reach, lake, or as in this case, a watershed. For more information on HUC, visit the USGS’s Water Resource pages at http://water.usgs.gov/GIS/huc.html.

It should be noted that Carlson considers the TSI^{CHL} to be the most accurate predictor of plant biomass; however, the Illinois EPA believes that the chlorophyll-a data collected by volunteers may have a greater margin for error. Therefore, in Illinois, the TSI^{TP} has been shown to be a better predictor for a hypereutrophic state.

Figure 9: Secchi Depth TSI Map



2014 VLMP

Using the Indices Beyond Classification (excerpt from Carlson, R.E. and J. Simpson. 1996.)

A major strength of TSI is that the interrelationships between variables can be used to identify certain conditions in the lake or reservoir that are related to the factors that limit algal biomass or affect the measured variables. When more than one of the three variables is measured, it is possible that different index values will be obtained. Because the relationships between the variables were originally derived from regression relationships and the correlations were not perfect, some variability between the index values is to be expected. However, in some situations the variation is not random and factors interfering with the empirical relationship can be identified. These deviations of the total phosphorus or the Secchi depth index from the chlorophyll index can be used to identify errors in collection or analysis or real deviations from the “standard” expected values. Some possible interpretations of deviations of the index values are given in the table below.

The simplest way to use the index for comparison of variables is to plot the seasonal trends of each of the individual indices. If every TSI value for each variable is similar and tracks each other, then you know that the lake is probably phosphorus limited and that most of the attenuation of light is by algae.

In some lakes, the indices do not correspond throughout the season. In these cases, something very basic must be affecting the relationships between the variables. The problem may be as simple as the data were calculated incorrectly or that a measurement was done in a manner that produced different values. For example, if an extractant other than acetone is used for chlorophyll analysis, a greater amount of chlorophyll might be extracted from each cell, affecting the chlorophyll relationship with the other variables. If a volunteer incorrectly measures Secchi depth, a systematic deviation might also occur.

Relationship Between TSI Variables	Conditions
$TSI^{CHL} = TSI^{TP} = TSI^{SD}$	Algae dominate light attenuation; TN/TP ~ 33:1
$TSI^{CHL} > TSI^{SD}$	Large particulates, such as Aphanizomenon flakes, dominate
$TSI^{TP} = TSI^{SD} > TSI^{CHL}$	Non-algal particulates or color dominate light attenuation
$TSI^{SD} = TSI^{CHL} > TSI^{TP}$	Phosphorus limits algal biomass (TN/TP >33:1)
$TSI^{TP} > TSI^{CHL} = TSI^{SD}$	Algae dominate light attenuation but some factors such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

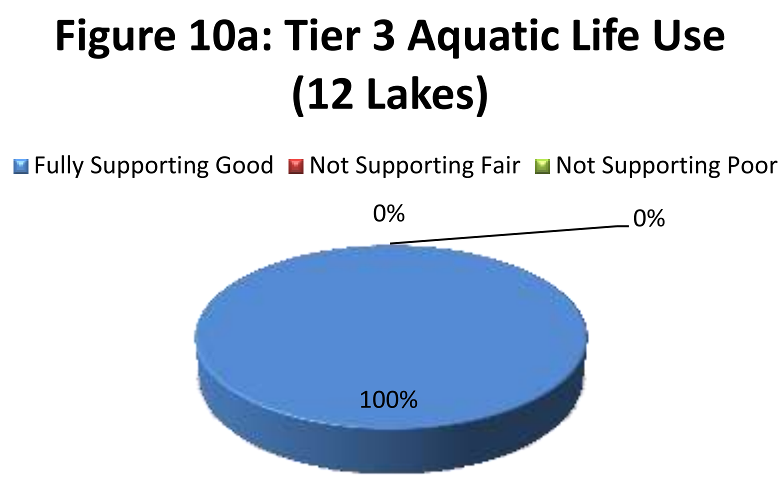
After methodological errors can be ruled out, remaining systematic seasonal deviations may be caused by interfering factors or non-measured limiting factors. Chlorophyll and Secchi depth indices might rise above the phosphorus index, suggesting that the algae are becoming increasingly phosphorus limited. In other lakes or during the season, the chlorophyll and transparency indices may be close together, but both will fall below the phosphorus curve. This might suggest that the algae are nitrogen-limited or at least limited by some other factor than phosphorus. Intense zooplankton grazing, for example, may cause the chlorophyll and Secchi depth indices to fall below the phosphorus index as the zooplankton remove algal cells from the water or Secchi depth may fall below chlorophyll if the grazers selectively eliminate the smaller cells.

In turbid lakes, it is common to see a close relationship between the total phosphorus TSI and the Secchi depth TSI, while the chlorophyll index falls 10 or 20 units below the others. Clay particles contain phosphorus, and therefore lakes with heavy clay turbidity will have the phosphorus correlated with the clay turbidity, while the algae are neither able to utilize all the phosphorus nor contribute significantly to the light attenuation. This relationship of the variables does not necessarily mean that the algae are limited by light, only that not all the measured phosphorus is being utilized by the algae.

Evaluation of Aquatic Life Use

The sample results were used to calculate TSI values for Secchi depth (128 lakes), TP (33 lakes), and chlorophyll-a (65 lakes) as seen in Appendix A: Table 4.

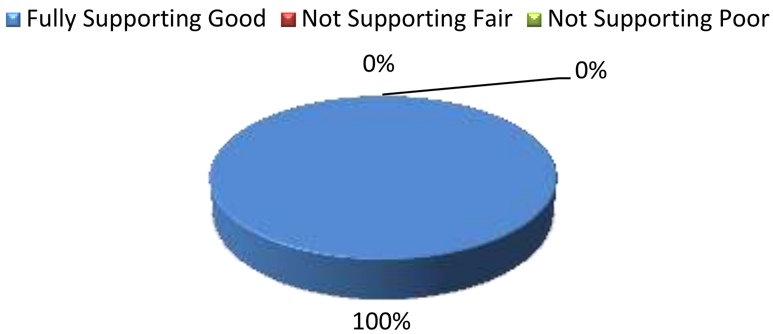
The TSIs, macrophyte coverage and NVSS medians are assigned point values as indicated under Weighting Criteria for ALU in the Data Evaluation section, above. All ALU components are summarized in Appendix A: Tables 7a and 7b.



As with TSI values, the ratings are weighted by using the two out of three rule when all three values are available, then by ALU^{TP} first and ALU^{CHL} second when only two TSI values. The ALU^{SD} alone cannot be used, unless NVSS was calculated in the absence of usable total Phosphorus data. Therefore, lakes only collecting Secchi information cannot be used to directly determine aquatic life use in a lake, but they can be compared with similar lakes of their type using TSI^{SD} and macrophyte coverage. All 66 lakes with chemical data available were rated Fully Supporting Good for aquatic life use.

Sixty-two (62) lakes had only Secchi monitoring data. This data was used to extrapolate ALU using the Secchi Depth TSI and the percent of macrophyte coverage over the lake bottom. A high and low NVSS range was estimated using the minimum value (0) and the maximum value (15), since water samples were not taken. Two final scores were then generated, a high value and a low value, providing a numerical range for the final ALU score. If the two values both fell into the same category, the lake was rated for that category. If the scores fell into different categories, a category range was determined to describe the outcome, either Two Category Range: Good-Fair or Two Category Range: Fair-Poor. Forty (40) lakes were rated Fully Supported Good and 22 were given a range of Two Category Range: Good-Fair for ALU.

Figure 10b: Tier 2 Aquatic Life Use (56 Lakes)



Overall, the lakes evaluated for their ability to support aquatic life are predominately (106 lakes) in Fully Supporting Good condition, 83 percent. The other 17 percent (22 lakes) fell into a range of Two Category Range: Good-Fair (Figure 10 Series, a-d).

Potential Causes: The potential causes for impairment for ALU in the 22 lakes rated by the range of Good to Fair are only identified by insufficient aquatic plant coverage for the lakes. Since these lakes fall into a potential range of use effect, a cause may not be necessary.

Potential Sources: The volunteer or lake managing body should look for the source of the cause. Appendix A: Table 12 contains a list of potential lake impairment sources to consider.

Figure 10c: Tier 1 Aquatic Life Use (62 Lakes)

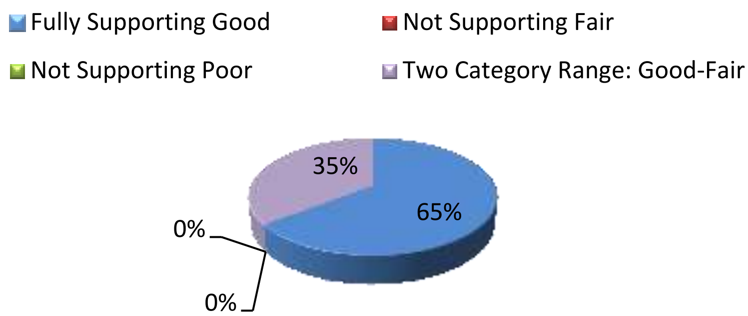
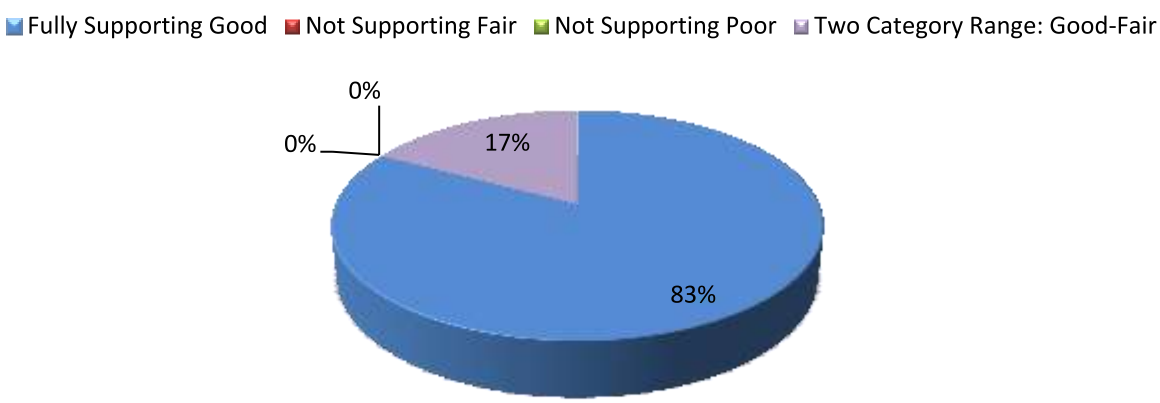


Figure 10d: Aquatic Life Use (128 Lakes)

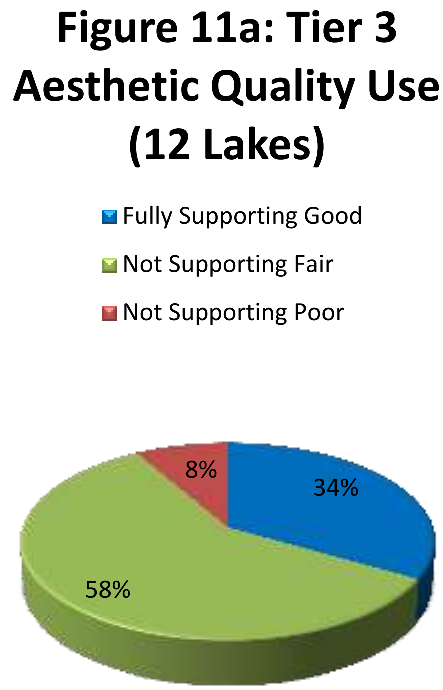


Evaluation of Aesthetic Quality Use

The sample results were used to calculate TSI values for Secchi depth, TP and chlorophyll-*a* as seen in Appendix A: Table 4.

The TSIs, macrophyte coverage and NVSS medians are assigned point values as indicated under Weighting Criteria for AQU in the Data Evaluation section. All AQU components are summarized in Appendix A: Table 8a and 8b.

As with TSI values, the ratings are weighted by using the two out of three rule when all three values are available, then by AQU^{TP} first and AQU^{CHL} second when only two TSI values. The AQU^{SD} alone cannot be used, unless NVSS was calculated in the absence of usable total Phosphorus data. Therefore, lakes only collecting Secchi information cannot be used to directly determine aesthetic quality conditions in a lake, but they can be compared with similar lakes of their type using TSI^{SD} and macrophyte coverage. Twenty lakes were rated Fully Supporting Good, forty-one were rated Not Supporting Fair and five were rated Not Supporting Poor for aesthetic quality use (See Figure 11 Series, a-d).



Sixty-two (62) lakes had only Secchi monitoring data. This data was used to extrapolate AQU using the Secchi Depth TSI and the percent of macrophyte coverage over the lake bottom. A high and low NVSS range was estimated using the minimum value (0) and the maximum value (15), since water samples were not taken. Two final scores were then generated, a high value and a low value, providing a numerical range for the final AQU score. If the two values both fell into the same category, the lake was rated for that category. If the scores fell into different categories, a category range was determined to describe the outcome, either Two Category Range: Good-Fair or Two Category Range: Fair-Poor. Two lakes were rated Fully Supporting Good (3 percent), 14 were Two Category Range: Good-Fair (23 percent), 78 were rated Not Supporting Fair (60 percent) and nine were rated Two Category Range: Fair-Poor (14 percent) for AQU (See Figure 11 Series, a-d).

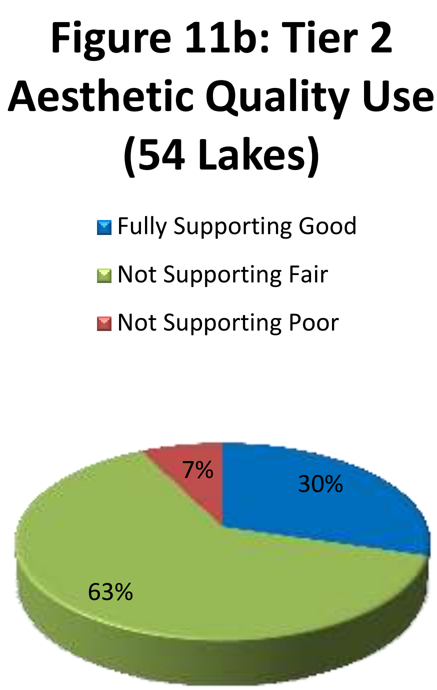
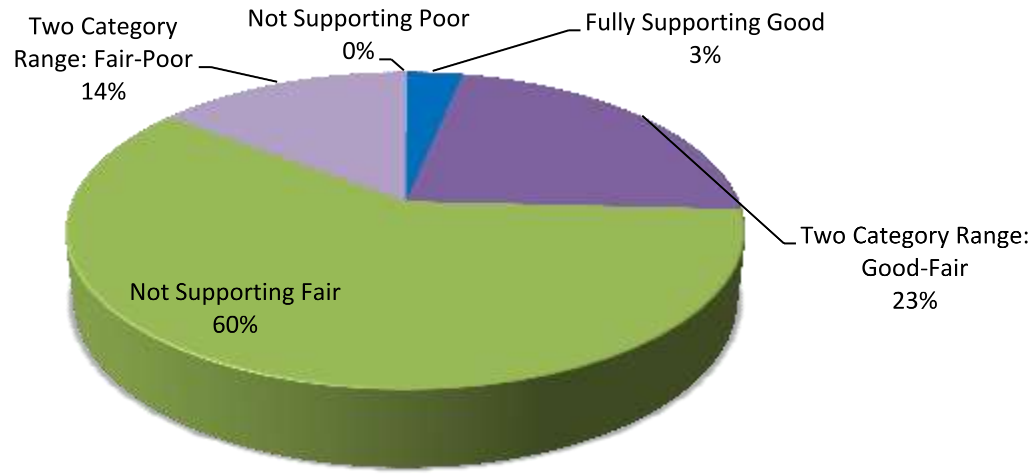


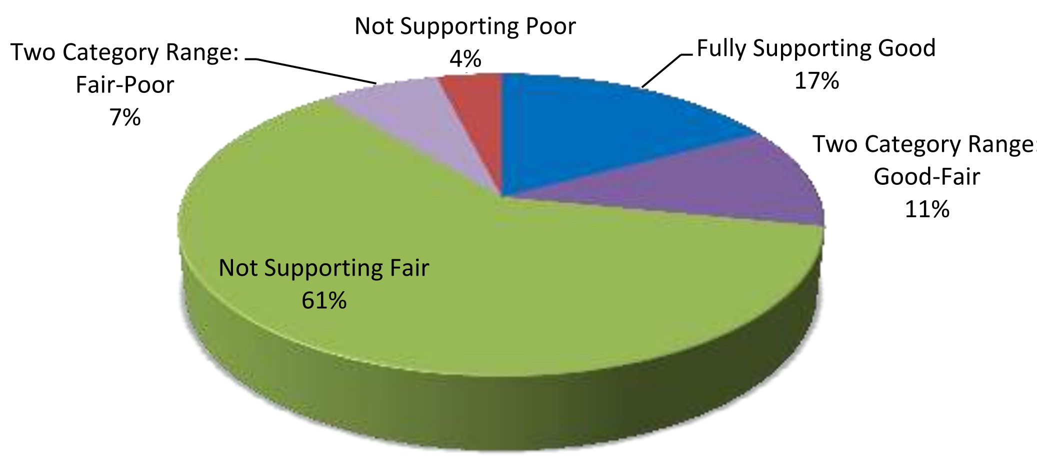
Figure 11c: Tier 1 Aesthetic Quality Use (62 Lakes)



Potential Causes: The potential causes for impairment for AQU in the 106 lakes rated less than Fully Supporting Good have a variety of causes: an over-abundance of aquatic plant coverage, severe algae blooms, high turbidity and total phosphorus levels over the WQS for lakes over 20 acres. The 14 lakes falling into a potential range of use effect may not have a cause associated.

Potential Sources: The volunteer or lake managing body should look for the source of the cause. Appendix A: Table 12 contains a list of potential lake impairment sources to consider.

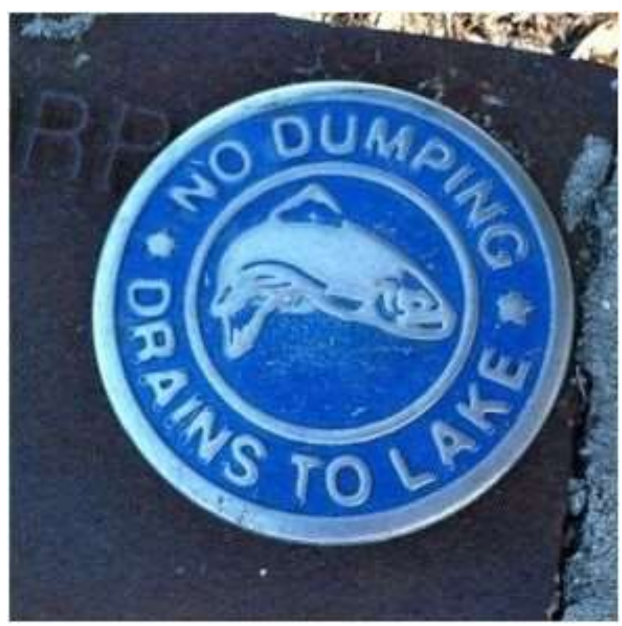
Figure 11d: Aesthetic Quality Use (128 Lakes)



Summary

Data from the Volunteer Lake Monitoring Program continues to show heavy loading of nutrients, such as phosphorus, into Illinois lakes. Data for the 66 lakes with total phosphorus values had a median range of 0.003 mg/L to 0.862 mg/L. The lowest single value for total phosphorus was 0.003 mg/L and the highest was 0.891 mg/L. This year's highest total phosphorus concentration was substantially lower than last year's 3.11 mg/L. The difference could be due to differences in climatic conditions in 2014 compared to 2013. The water quality standard for Illinois surface water is 0.05 mg/L (Appendix A: Table 9b). Median total phosphorus values at 29 lakes were below the water quality standard, but nine of the 29 lakes had at least one value over 0.05 mg/L. The other nutrient of concern is Total Nitrogen (which is adding Nitrate/Nitrite values to TKN). Total Nitrogen values had a median range of 0.19 mg/L to 7.71 mg/L. Six lakes had the lowest single values for total nitrogen as "not detected" (meaning both Nitrate/Nitrite and TKN values were both "not detected") which (for laboratory purposes) is less than 0.19 mg/L and the highest was 15.55 mg/L at Lake Vermilion in the middle of June.

Other than nutrients, macrophyte coverage appears to be the number one factor that determines favorable conditions for both aquatic life and aesthetic quality uses. Thirty-six of the 128 lakes studied had good macrophyte coverage for supporting aquatic life while maintaining good recreational use



Setting Goals with Volunteer Data

There are a number of options for improving the water quality of a lake – from picking up litter to implementing best management practices (BMPs) in the watershed. BMPs have been developed for construction, cropland, and forestry, as well as other similar land-use activities. Managers of lakes and streams can focus their best management practices to control water runoff, erosion, nutrient loading and contaminant loading. Appendix A: Table 10 contains a long list of best management practices with a set of priorities assigned at low, medium, or high for agriculture, construction, urban runoff, hydrologic modification, resource extraction, groundwater, and wetlands.

The volunteer data helps to identify and justify the use of a particular set of BMPs. Are the issues caused by nutrient loading, high suspended solids, or aquatic plant growth; or a combination of the three? Are the plant issues caused by invasive species? If so, maybe there is grant money through a local, state or federal program to eradicate that invasive species. In all cases of grant applications, data to confirm your need is valuable.

Illinois EPA publishes a series of fact sheets called Lake Notes that provide information on a wide range of lake- and watershed-related topics. Aquatic Exotics, Aquatic Plant Management Options, Common Lake Water Quality Parameters, Lake Dredging, Shoreline Bugger Strips, and Where to Go For Lake Information are just a few of the subjects covered by the fact sheets. They can be found at the link below.

What Does My Data Mean?

Grants Available to Control Nonpoint Source Pollution in Illinois

319 Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address water quality issues relating directly to nonpoint source pollution. Funds can be used for the implementation of watershed management plans including the development of information and/or education programs and for the installation of best management practices.

IEPA receives these funds through Section 319(h) of the Clean Water Act and administers the program within Illinois. The maximum federal funding available is 60 percent. The program period is two years unless otherwise approved. This is a reimbursement program.

Applications are accepted June 1 through August 1. If August 1 is a Saturday or Sunday, the deadline becomes the prior Friday before 5 p.m. At this time, electronic submittals are not accepted. Please mail applications to the address provided to the right.

Illinois Environmental Protection Agency
Bureau of Water
Watershed Management Section
Nonpoint Source Unit
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Contact Number: (217)782-3362

Links for 319 Grants

- Section 319 Request for Proposals
- Section 319 Application
- Section 319 Application Instructions
- Section 319 Certifications and Grant Conditions

Illinois Environmental Protection Agency
Bureau of Water
Surface Water Section
Lakes Unit
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

The **Priority Lake and Watershed Implementation Program** (PLWIP) began in July 1997 with funds provided through "Partners for Conservation", a long-term, comprehensive, Illinois natural resource protection bill. PLWIP is a reimbursement grant program designed to support lake protection, restoration and enhancement activities at "priority" lakes where causes and sources of problems are apparent, project sites are highly accessible, project size is relatively small and local entities are in a position to quickly implement needed treatments. Priority lakes are identified by the Agency in a report entitled, Targeted Watershed Approach – A Data Driven Prioritization (Document No IEPA/BOW/97-004). In general, priority lakes are unique, high quality aquatic resources, and/or serve multiple purposes (recreation and public water supply) and are in need of protection or restoration.

Any inland lake owner is eligible to apply for a PLWIP grant if the following criteria are met: A) The lake is publicly owned, B) The causes and sources of pollution are apparent, C) The project site is highly visible, D) The project site is easily accessible, E) The project size is relatively small, F) Local management is in a position to quickly implement necessary treatment (Project must be completed within 18 months), and G) Recipient must obtain local, State and Federal permits (i.e. 404 permit).

The recipient must also be willing to: 1) Display an Illinois EPA PLWIP sign (provided by Illinois EPA) in a visible area of the lake for a minimum of five years, 2) Run an ad in the local newspaper before and after project implementation about Conservation 2000 and funding through Illinois EPA, 3) Maintain the project area for a minimum of ten years, and 4) Submit quarterly progress reports.

Project Proposals are accepted through June 30th of each year, contingent on available funding.

Contact Number: (217)782-3362

Links for PLWIP Grants

- Home Page
- Priority Lake and Watershed Implementation Program Project Proposal Form (Under Surface Water Forms)

References

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Glossary of Terms

Algae: a group of photosynthetic eukaryotes that are single celled, colonial, or filamentous aquatic plants, often microscopic.

Algal bloom: A condition which occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water.

Alkalinity: A measure of the capacity of water to neutralize acids. It is a measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. (Expressed as milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$), or as micro equivalents per liter (µeq/l). 20 µeq/l = 1 mg/L of $CaCO_3$.)

Ammonia: A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO_3^-) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for indigenous aquatic life is 0.1 mg/L of unionized ammonia. At a pH of 7 and a temperature of 68^o Fahrenheit (20^o Celsius), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

Anaerobic: Any process that can occur without molecular oxygen; also applicable to organisms that can survive without free oxygen.

Aquatic Invasive Species (AIS): AIS is a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Aquatic invertebrates: Aquatic animals without an internal skeletal structure such as insects, mollusks, and crayfish.

Beneficial use: The uses of a water resource that are protected by state laws called water quality standards. Uses include aquatic life, recreation, human consumption, and fish or wildlife habitat.

Benthic: Living in or on the bottom of a body of water.

Benthos: Collectively, all organisms living in, on, or near the bottom substrate in aquatic habitats (examples are oysters, clams, burrowing worms).

Best management practices (BMPs): Management practices (such as nutrient management) or structural practices (such as terraces) designed to reduce the quantities of pollutants — such as sediment, nitrogen, phosphorus, and animal wastes — that are washed by rain and snow melt from lands into nearby receiving waters, such as lakes, creeks, streams, rivers, estuaries, and ground water.

Biomass: The total quantity of plants and animals in a lake. Measured as organisms or dry matter per cubic meter, biomass indicates the degree of a lake system's eutrophication or productivity.

Blue-green algae: Algae which are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N_2) from the air to provide their own nutrient.

Chlorophyll: Green pigments essential to photosynthesis.

Chlorophyll-a: A green photosynthetic pigment found in the cells of all algae and other plants. The chlorophyll-*a* level in lake water is used to estimate the concentration of planktonic algae in the lake.

Chlorophyll-*b*: A type of chlorophyll found in green algae and euglenoids. Both of these are good food for zooplankton which is good fish food.

Chlorophyll-*c*: A type of chlorophyll found in diatoms and golden brown algae. Both of these are good food for zooplankton which is good fish food.

Conductivity: The ability of water or other substance to carry an electric current.

Color: Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. Color also affects light penetration and therefore the depth at which plants can grow.

Cultural Eutrophication: The enrichment of lakes with nutrients (especially phosphorus) as a result of human activity, resulting in an acceleration of the natural ageing process of the lake.

Detritus: Fragments of plant material.

Diatoms: Any number of microscopic algae whose cell walls consist of two box-like parts or valves and contain silica.

Dinoflagellates: Unicellular biflagellate algae with thick cellulose plates.

Dissolved Oxygen: Dissolved oxygen is the amount of oxygen dissolved in the water. The DO concentration in water is affected by the water temperature, water quality, and other factors.

Epilimnion: the upper (usually warmer) circulated zone of water in a temperature stratified lake.

Erosion: Wearing of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Euphotic: the zone of vertical light penetration in a lake.

Eutrophic: water which are rich in plant nutrients and capable of supporting high amounts of plant and animal growth (Secchi transparency less than 6.6 feet and TSI 50 to 70).

Eutrophication: the lake aging process via nutrient enrichment and sedimentation; both a natural and human induced process.

Hypereutrophic: a lake with extreme level of nutrients and nuisance plant growth, often as a result of human activities (a TSI greater than 70).

Hypolimnion: the lower (usually cooler) non-circulated zone of water in a temperature stratified lake.

Invasive Species: An alien species whose introduction does, or is likely to, cause economic or environmental harm to human health.

Lake: A man-made impoundment or natural body of fresh water of considerable size, whose open-water and deep-bottom zones (no light penetration to bottom) are large compared to the shallow-water (shoreline) zone, which has light penetration to its bottom.

Limnology: The scientific study of the life and phenomena of lakes, ponds and streams.

Littoral Zone: The near shore shallow water zone of a lake, where light penetrates to the bottom and aquatic plants grow. Some shallow ponds are entirely littoral.

Macroinvertebrate: Any non-vertebrate organism that is large enough to be seen without the aid of a microscope.

Macrophyte: water plants that are visible to the unaided eye.

Mesotrophic: waters intermediate in eutrophy between oligotrophic and eutrophic (Secchi transparency 6.6 to 12.1 feet and TSI 40 to 50).

Metabolism: the sum of the physical and chemical processes ongoing in all living things.

Methemoglobinemia: a condition brought on by drinking water high in nitrates, that reduces the ability of blood to carry oxygen and may also cause respiratory problems. Infants are particularly at risk.

Native Species: A species naturally occurring of originating in a geographical region or in a specific ecosystem.

Nonpoint source (NPS) pollution: Unlike pollution from industrial and sewage treatment plants, NPS pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands and even our underground sources of drinking water. It has been determined that over 60 percent of the (national) documented water pollution problem can be traced to nonpoint sources.

Nutrients: Chemicals that are needed by plants and animals for growth (e.g., nitrogen, phosphorus). In water resources, if other physical and chemical conditions are optimal, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

Oligotrophic: water with low concentrations of plant nutrients and hence relatively low amounts of plant and animal growth (Secchi transparency greater than 12.1 feet and TSI less than 40).

Online Lakes Database: An online interface for volunteer lake monitors to input their data into the IEPA Lake's Data Management System. It also provides a means for all citizens to view current and historical water quality information on monitored lakes. Database currently contains only those lakes sampled since 1999. Previous to 1999, all data may be accessed through USEPA's **STORET**.

pH: A measure of the acidic or basic (alkaline) nature of water, relating to the number of hydrogen ions. A pH of 7 is neutral. Acid waters are below 7; alkaline waters are above 7.

Pheophytin: The dead chlorophyll of algal cells. Can indicate when an algal bloom dies off.

Phosphorus: One of the major nutrients needed for plant growth. Phosphorus is the critical nutrient for algae growth in lake and ponds.

Photosynthesis: the process by which green plants use sunlight, water, and carbon dioxide to produce oxygen.

Plankton: Small organisms that float passively (or swim weakly) in open water. The two groups of plankton are: phytoplankton, also called algae; and planktonic animals, also called zooplankton.

Pollutant: A contaminant that adversely alters the physical, chemical, or biological properties of the environment. The term includes nutrients, sediment, pathogens, toxic metals, carcinogens, oxygen-demanding materials, and all other harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities which collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Protoplasm: the living substance of in a cell (includes the cytoplasm and nucleus).

Representative Site: generally is the deepest area of the lake and is called Site 1.

Saturation: the maximum concentration that water can hold (of any substance, in this case oxygen). This is a function of temperature and pressure.

Secchi Disk Transparency: the depth in the water column that an eight inch, black and white disk disappears from view. Two or three time the Secchi depth is the depth that sunlight can reach into the water column and thereby support plant growth. A healthy plant community is needed for animal (fish) habitat within the lake.

Sediment: Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.

STORET: USEPA's old national data storage database; it is housed in a computer mainframe system.

Stratification: The layering of water due to differences in density. Water's greatest density occurs at 39^{o} Fahrenheit (4^{o} Celsius). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer **(epilimnion),** which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water **(hypolimnion)** is called the **thermocline**.

Super-Saturation: a concentration of a substance (in this case oxygen) above the maximum concentration that water can hold at a given temperature and pressure. This can happen when temperature or pressure changes, or as a result of biological activity.

Suspended solids: Suspended solids refer to small solid particles which remain in suspension in water as a colloid or due to the motion of the water. It is used as one indicator of water quality

Thermal Stratification: As lake water is warmed in the summer, the water in the deep pond or lake is layered into three levels: 1) warmer (less dense) epilimnion layer at the surface; 2) the thin thermocline or transition layer; and 3) the cold and deep hypolimnion layer.

Thermally Stratified: Lake water often separates into zones or layers by temperature difference.

Thermocline: the zone in a temperature-stratified lake between the epilimnion and the hypolimnion, also referred to as the "metalimnion."

Total Phosphorus: A measure of all forms of phosphorus (organic and inorganic) in water.

Total Suspended Solid (TSS): The weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles. Total suspended solids are differentiated from total dissolved solids by a standardized filtration process, the dissolved portion passing through the filter.

Transparency: A measure of water clarity that, in lakes and ponds, indirectly measures algal productivity. Transparency is determined by the depth at which a Secchi disk lowered into the water column is no longer visible.

Trophic: A level of nutrition, nutrient enrichment within a lake.

Trophic State Index (TSI): A simplified index of biological productivity in lakes.

Turbidity: A measure of the amount of light intercepted by a given volume of water due to the presence of suspended and dissolved matter and microscopic biota. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

Volatile suspended solids (VSS): That fraction of suspended solids, including organic matter and volatile inorganic salts, which will ignite and burn when placed in an electric muffle furnace at 550 °C for 15 minutes.

Watershed: A region or area divided by points of high land that drains into a lake, stream, or river.

Watershed Based Plan: A watershed based plan is a document designed to protect and improve water quality by controlling nonpoint source pollution and related water quality problems. Such plans provide an integrated, holistic process to effectively and efficiently protect, enhance and restore the physical, chemical and biological integrity of water resources within a defined hydrologic area (watershed). Watershed based plans present assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources related to development and implementation of the plan. Watershed based plans should be consistent with the nine minimum elements of watershed based plan as defined by USEPA watershed based plan guidance, the Chicago Metropolitan Agency for Planning's Guidance for Developing Watershed Action Plans in Illinois, total maximum daily load (TMDL) implementation plan requirements, and current watershed planning principles.

Water quality standards: Established limits of certain chemical, physical, and biological parameters in a water body; water quality standards are established for the different designated uses of a water body.

Wetlands: Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Zooplankton: microscopic animals found in the water of lakes and rivers.